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Part, I

Part I

Historical sketch of the Origin and Progress of the Ganges Canal

Chapter I

Preliminary Period under the Directorship of Lieut. Colonel P. T. Cautley
From 1839 to 1845

The direction of the drainage on the Southern Slopes of the Himalayas throughout the Provinces of Upper India lying to the North west; the character of the Rivers which constitute this drainage; and the topographical features of the Country through which it passes; point out by unmistakeable signs, a region designed by Nature as a great field for artificial Irrigation. These Rivers after their debouche from the mountains enter upon a Champaign Country with a rapidly decreasing slope, and from the parallel direction which they assume in their passage to the Indus on one side, and to the Ganges on the other, divide the country into ~~strips~~ sections of a ~~greater~~ larger or ~~less~~ smaller width, all of which both in soil and declivity of surface possess in themselves every requisite

for

for Irrigation. The steep slopes that exist at the immediate debouche from the mountains enable the Engineer by a proper adaptation of levels in his artificial channels, to obtain a command of water, which places the whole country under his control; the benefits in fact that he is able to confer upon it by means of Irrigation, are limited by the volumes of water which are ~~placed~~ at his disposal, and his greatest, it may be said his only difficulties are in the neighborhood of these steep slopes, and in their connection with Mountain Torrents. From the above description it will be evident that a Canal whose Head supply is derived from the higher levels of these Rivers, and whose course is carried parallel to them, must inevitably act as a ~~supply~~ feeder for Irrigation; this plain fact is appreciated by every villager who resides in the ~~neighborhood~~ vicinity of these rivers, and who although he ~~has~~ may have not the means, in the possession of land, of turning it to account in Irrigation, yet adopts the principle in ~~cutting~~ designing Cuts to turn his Corn Mills, or in ~~making~~ establishing Dams for the application of his fishing apparatus. On a larger Scale this same fact has been taken advantage of by our Patan and Moghul predecessors not only on the Jumna, but on the Rivers in Rohilkund and in the Punjab; On the Jumna especially the Canals on the East

and

and West of that River, which within the last thirty years have been restored by the British Government, are vestiges of its early appropriation; the Husli Canal from the Ravi in the Punjab is of the same character; ~~and~~ Rohilkund and the countries bordering on the Indus throughout their length and breadth offer a variety of specimens of canals of more humble pretensions but proving in every case that the method of obtaining irrigation was perfectly understood. With so many examples before us, no great exertion of intellect was required to arrive at the conclusion that the system might be generalized. With a map before us it was fair to infer, ~~[illegible]~~ that if canals had been so easily ~~[illegible]~~ [illegible] from the Jumna ~~[illegible]~~, similar canals might, [illegible], be taken from the Jhelum, from the Chenab, from the Ravi, from the Sutlej, from the Ganges, from the Ramgunga, or from any other of the Rivers that after leaving the mountains pass over a country possessing in its contour every qualification for enabling the Engineer to make the best possible use of the water that could be ~~brought to bear upon~~ [illegible] it.

It was under these well known characteristics of surface, and with the example of the Jumna Canals before us, that the idea of taking a line from the Ganges

Ganges originated. On the natural difficulties existing on both sides of the Jumna and immediately below the point where it leaves the mountains, that had notoriously limited its utilization as a source of supply for a Canal: but so little was known of the detail of these difficulties, or ~~to what~~ to what extent the surface of the country was affected by them, that ~~on the reason denominating the Boodhi Gunga from the circumstance of its relative position to the Ganges being similar to that of the Boodhi Jumna from which the Eastern Jumna Canal supply is taken~~, with the main stream of the Jumna, was considered ~~an equally appropriate position for the head of the Ganges Canal~~. It was ~~at~~ a point near the village of Radshanpoor marked **A** in Diagram **I**, that the first line of levels was taken; the extraordinary elevation of the country at **D**, ~~on the crown~~ from whence the high land of the Doab commences, was then not known by those interested in Irrigation. At the point where the line of levels from **A** crossed the boundary of the high land, the rise of country ~~from the low to the high land~~ was equal to 63.225 feet; the possibility of using the proposed Boodhi Gunga, ~~Khadir~~, as a head for a Canal was totally out of the question, but the same course of reasoning which had led to the adoption of the Boodhi Nunga in the

the first instance, further to that of a point situated on the main River at higher levels; as it was clear that by proceeding higher, and leaving [illegible], the certainty of discovering a line upon which a Canal might be traced was unquestionable.

Before entering upon the narrative of the rise and progress of the works on the Ganges Canal, a few words on former projects for the irrigation of the Districts which are to be placed under its influence may be appropriate; so far as I am aware, these are only two in number: the first, a Muhummud Aboo Khan's Canal which appertains to a period prior to the accession of the British. The second a project of Captain Debudé of the Bengal Engineers submitted to Government in 1807.

The Canal of Muhummud Aboo Khan, the remains of which still exist in the neighborhood, and to the Northward of Meerut, consisted of a Cut made from the west Kalli Nuddi near the village of Rampoor, to the head of a small tributary of the East Kalli Nuddi, called the Khodara Nulla, which rises near the village of Deorala; the length of this Cut did not exceed 12½ Miles, and its dimensions judging from the existing hollow could not have exceeded 15 feet in breadth; the water after reaching Deorala must have passed down the Khodara Nulla to the town of Meerut

in

in the neighbourhood of which there are many groves and gardens, and it is supposed that it was for the purpose of supplying water to these ~~groves and gardens~~ that the Canal was originally projected; there is no tradition, however, of its existence as a running ~~line of~~ water, although there is no reason to doubt that for a season at least ~~[illegible]~~. The ~~design~~ was evidently one of those which from the circumstances ~~under which~~ affecting it ~~[illegible]~~ its supply and from the total absence of all masonry works, could not have been classed under the head of permanent works of Irrigation. The west Kalli Nuddi at the village of Rampoor, although ~~[illegible]~~ a perennial stream, is one of those lines of drainage which during the periodical rains is subject to very great floods; the river meanders through a valley of considerable extent, and during the dry months is 30 feet below the level of the country, or below that land ~~on~~ over which Muhummud Aboo Khan's Canal was ~~[illegible]~~ carried; the Canal was merely excavated to a few feet in depth, and water was supplied ~~to that channel~~ from a lake formed by throwing an embankment ~~on~~ across the bed of the west Kalli Nuddi. The flooding of the valley by this system of damming up its waters, must have done extraordinary damage to the neighbouring ~~[illegible]~~ cultivation.

The

the amount of money and labor expended on an Embankment of proportions sufficient to gain the Engineers object must have been very great; and the necessity for an annual reconstruction of a work which was ~~necessarily~~ inevitably destroyed during the rain floods, and the certainty that water could only have reached the mouth of the Canal during the dry months of the year, are facts which reasonably lead us to conclude that no great benefit was ever derived by the cultivators on the high lands in its vicinity.^ The line of the present Ganges Canal almost crosses the old line of Aboo's Canal (as it is now called) at an angle of 30° near the village of Jowalapoor, and by a singular prevision of purpose, that portion of it which approaches the Canal from the West Kallee nuddee at Furreedpoor is now converted into an Escape, for throwing the waste water from the Canal into the valley of the river. The plan above described as carried into effect by Aboo Khan is an illustration of Canal design which is by no means uncommon in this part of India: it possibly originated with the inability of the owners of the site upon which the bund was erected, to take possession of land at a higher level of the river's course, and partly from the apparent magnificence of a design which in converting dry land into

^ Muhummud Aboo appears to have made two attempts at obtaining water from the West Kallee Nuddi viz: that at Deenpoor before described, and a newer one from the village of Furreedpoor: traces of both these cuts which joined at a point near Jowalagurh were distinctly discernible at the date of my surveys.

into a Tank realised in the eyes of the multitude the acts of the Jinns or Genii of Eastern Fable. Over the Kirsunni or Kristna River which runs Eastward and parallel to the West Kalli nuddi, and close by the towns of Jullalabad and Shannabhoun, a similar work appears to have been executed during the short period of Endam Nadir's Government. The Bund thrown over the River at this point was of moderate extent in comparison with that at Rampoor, but its purposes were the same. Bunds of this sort were by no means uncommon in the earlier history of these districts, and at the present day every River in the Tract of Country between the Jumna and Ganges, is interrupted in the upper part of its course by Embankments more or less extensive for the purpose of collecting a supply of water for Irrigation. In the Delhi and adjoining Districts as well as in the Districts without Irrigation, embankments of the above description is extensively used. —

Captain ~~[illegible]~~ Debude's project which I have referred as the second instance recorded of an attempt to supply the means of Irrigation to the lands on the Right of the Ganges, was in fact a mere enlargement of the scheme originated by Mahummed Ameer Khan, in so far that the plan of damming up the West Kalli

nuddi

Nuddee and raising the water until it was able to afford a supply to a Channel excavated on high levels, was resorted to; ~~Major~~ Captain Debude in fact adopted the site of Mahummud Abookhan's Embankment on the West Kalli Nuddee as the position of the head of his Canal, and although the works for irrigation which were projected by him were calculated to be of more extended benefit, they were as all our Canal undertakings had been up to that period, a mere attempt to restore, and in restoring to improve upon the Acts of our Predecessors.—

H. I have before explained that Mahummud Abookhan's Canal was a mere Cut, for the apparent purposes of giving water to the Town of Meerut and the Gardens in its neighborhood; ~~Major~~ Captain Debude's idea was to extend the benefits of the introduction of water on the high levels, by carrying a Canal to the South through the Meerut, Bolundshuhur, and the Northern portion of the Allyghur Districts: the possibility of obtaining a supply for this purpose from the Ganges River under the difficulties that were supposed to exist, did not enter into his calculations, and the whole bent of his mind was directed to devising the best and most economical method of ~~[illegible]~~ turning to profitable account the ~~whole~~ available supply ~~to be [illegible]~~ furnished by the perennial Streams connected with the West Kalli Nuddee

and

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and its Tributaries.

The Hindun River which in character is similar in every respect to the West Kalli Nuddi, runs parallel to and joins the latter River on its Right bank at a point about 10 miles below the village of Rampoor, the site of Muhummud Aboo's lines Embankment. The supply of water in the Hindun River is continuous during the year, and as is the case with the West Kalli Nuddi, increases during the rainy months to a very considerable volume. It was ~~Major~~ Captain Debude's intention to throw Embankments with Masonry Sluices over both these Rivers, to create by ~~these~~ such means two gigantic reservoirs connected by an excavated Cut, and by these works to raise the level of the water to a sufficient height, to enable him to pass it off at a Canal head which was situated at Rampoor.

It would be out of place here to enter into a detail of a project which, although it was never carried out may be considered as the germ of future operations for the economical application of waters now allowed to run to waste, it will be sufficient to state that ~~Major~~ Captain Debude's scheme involved the construction of two very extensive Masonry Dams with their Embankments over the Rivers above described, the Cost of that on the Hindun being 5,?00, and

that

that in the West Kalli Nuddi, 25 feet above the beds of their respective Rivers; it involved, moreover, a sacrifice of a considerable tract of very valuable land which would have been inundated on the formation of the Reservoirs, There would be great uncertainty ~~and the Question of~~ whether during the rainy months, or ~~during~~ from that period when irrigation is especially required for Sugar Cane and Rice, the regularity of supply could have been insured, & whether even during the dry months, the reservoirs, being subject ~~at the same~~ to ~~the contingencies of~~ diminution of volume from the effects of evaporation and absorption, could keep up a supply sufficient for the purposes of irrigation, ~~was doubtful~~ and would in all probability uncertainty on these points lead to the sacrifice of the project. The plans and papers were submitted in great detail to Lord William Bentinck who was then Governor General, with an Estimate amounting to about Three Lakhs of Rupees. ~~The~~ The difficulties as well as danger of interfering with the courses of Rivers liable as the Hindun and West Kalli Nuddi are to floods of the most violent description during the rainy months, were by no means unappreciated by Captn. Debude but the times during which he carried on his labors, were not those when the advantages of irrigation

irrigation were understood and recognized as they were a few years afterwards; Captain Debude's means were limited, not only by the instructions under which he acted but by the certainty that Estimates to a large amount would not be received by the Government with the slightest satisfaction; whatever, therefore, may have been Captain Debude's views as to the feasibility of obtaining a supply of water from the Ganges on the principles that had already been adopted on the Jumna River, no reference is made to them in any of the papers that have come under my cognizance, and his ultimate removal to a superior appointment in Calcutta, which took him entirely from the scene of his early Engineering inquiries in the North West Provinces, gave a new direction to his thoughts, and introduced him to new fields wherein his talents were as profitably exerted as they had been heretofore.

II. As time advanced, and the results of the Jumna Canals had proved to the Government that the money which had been laid out on these works had been most profitably expended, that independently of paying of their own expenses annually, they were both directly and indirectly increasing the Land Revenue, improving the resources of the country, and greatly benefitting

the

the Community; views of Irrigation on a more extended scale ~~[illegible]~~ was freely advanced. ~~[illegible]~~ Rohilcund which had from time immemorial been the field of very extensive irrigation, abandoned as it is true by the anarchy that had prevailed previous to its settlement as a Regulation province, but still containing within itself all the vestiges of its ancient Canals, watercourses and Dams, was one of the first ~~Districts~~ localities that came under the notice of Government. A series of papers illustrative of ~~[illegible]~~ this Irrigation was submitted to Colonel Colvin, then Superintendent of Canals at that time, and subsequent inquiries led to the deputation of that officer to report upon certain projects for the immediate restoration of some of the Canals. Colonel Colvin's report and the favorable opinion ~~that~~ expressed of the extraordinary capabilities of the District led to the appointment of an Engineer Officer to superintend the execution of a line of Canal near the town of Nugeena; the completion of this work, and afterwards the appointment of Captain William [illegible], of the Bengal Engineers to carry out the intentions of Government in extending the means of Irrigation throughout the Province, led to the establishment of ~~[illegible]~~ a permanent system ~~[illegible]~~ under an Officer entitled "Superintendent of Canals and Embankments" in

"in Rohilkund" Captain Jones who ~~still continues to~~ held this appointment up to the year 1854, is the author of a variety of reports on the subject of irrigation in the province. —

II. In 1836, Colonel Colvin left India, having devoted a long period of his life to the Canals in these provinces, and having left a spirit of emulation amongst his successors, the result of which has been favorable in no small degree to the advancement of those objects to which so much of his time had been devoted. —

III. In 1837, the Deyra Doon or valley between the Jumna and Ganges, ~~and~~ lying north of the Saharunpoor District from which it is separated by a border of mountains called the Sewaliks, became the field of inquiry for Irrigation purposes; the valley itself was intersected by running Rivers and the Himalayas which bounded its northern front supplied from numerous perennial streams of greater or less ~~extent~~ volume ample means for providing irrigation to the high lands ~~[illegible]~~ forming ~~[illegible]~~ the northern front of the valley. The examination of ~~this~~ the field thus ~~so~~ favorable in its means for irrigation, has led to the execution of numerous works, the Beejapoor, Rajpoor, and Kutta Pathur Canals have been already executed; two other lines, which come under the designation of the Kalunga and Jussadhara

Canals

Canals have been delayed in execution merely from want of Executive Superintendence: and numerous unexamined streams ~~which are~~ now lost in the Ravines and Forests which skirt the base of the Himalayas, are in all probability as capable of being turned to useful account as those which have been already worked upon. —

About the same period that the Doab Irrigation was brought to the notice of the Government, Major Baker, the Superintendent of the Delhi Canals was occupying himself in many useful enquiries as to the means of supplying irrigation to the Country lying between the Jumna and the Sutlej Rivers; the results of these enquiries have been published by the Government of the North Western Provinces ~~[illegible]~~. The Guggur ~~[illegible]~~ which leaves the hills at the Eastern extremity of the Pinjore Valley, was the only line of perennial Drainage that ~~[illegible]~~ prior to the period of Major Baker's enquiries had been taken up as a supply for Irrigation; ~~[illegible]~~ its being brought under the consideration of Government at all was, I believe, due to certain disputed rights of water claimed by an independent Sikh Chief (the Puttialla Raja) through whose territories a portion of its course

run,

runs, ~~[illegible] to better [illegible]~~ Engineer Officers had been deputed to establish works for regulating ~~the [illegible]~~ and for equalizing the available supply ~~[illegible]~~. The means of Irrigation ~~[illegible]~~ offered by the Ghuggur were however comparatively small and were confined entirely to the establishment of earthen Dams at fixed intervals, for the formation of Reservoirs from whence the Irrigators drew their water; the value of the Ghuggur as an Irrigating ~~[illegible]~~ stream was in fact confined to a narrow tract on each edge of the River. ~~Major Baker's object [illegible] was to look to some more comprehensive method of Irrigation, derived from a supply that would not fail, and which would benefit the distant lands lying to the North and West of Ferozepore, as well as those which situated on the right or South of the Delhi Canal, were from their elevated position incapable of enjoying its benefits.~~

distant lands to the [illegible]

The Sutlej River on its approach to the plains at Roopur takes a considerable turn to the West regaining its Eastern direction by a sharp & abrupt bend; the course of the River at this point forming a long loop, the neck of which is not more than 7 miles in breadth. It was above this loop to a point ~~[illegible] the advantages of slope gained by the course of the River~~

~~Point.~~

that Major Baker's attention was first directed as promising an admirable site for the head of a Canal; to this idea however the mountain ridge which leads to the deviation of the River from its direct course offered an insurmountable barrier; the highest accessible point [illegible] was selected by Major Baker for the commencement of the [illegible]

ical - ~~Major Baker [illegible] point for the head of a Canal the course of~~ which was to ~~[illegible]~~ pass centrically through the country bounded by the Sutlej and the Jumna. The results of the survey showed the feasibility of a project which would provide Irrigation to an immense extent of country the more western parts of which ~~[illegible]~~ are at present, [illegible] ~~[illegible] the means of Irrigation~~ even from wells, and ~~[illegible]~~ at the same time would supply water for [illegible] regions ~~[illegible]~~ now reduced to [illegible] ~~reduced [illegible] to a state of desert~~.

Major Baker having satisfied himself ~~with~~ the fact that the Sutlej might be ~~[illegible]~~ made use of to supply for Irrigation, and having carefully examined the country lying between Roopur and Kurnal; Submitted his views to the Government. - At this time a great portion of the land over which the projected Canal would have taken its course was in the hands of Independent Sikh Chiefs and others who recognized no further control by the British Government than that offered by treaty in their protection: the regular plans and Estimates were therefore submitted to the Government, and the whole Question, interesting as it was at the time was allowed to drop. - Laying aside the reasons for adopting this course which I have no doubt were in every way sufficient, but at the same time looking ~~aside~~ to the extraordinary benefits that the Country would have derived from the introduction of water, and the con-
-se-

sequent establishment of villages and agriculture on a large ~~surface of country~~ [area] which is now a wilderness, knowing, moreover, the singularly fertile nature of the soil at those points where the blessings of water are ~~disseminated~~ [felt] even in ~~the~~ [their] most ~~parsimonious sense~~ [limited extent]; looking to the predatory life of the scattered population now existing, and contemplating ~~a~~ [the certain] change to that of agriculture with all its concomitant ~~blessings~~ [advantages]; the causes that led to the abandonment of Major Baker's project may I think be regretted, and we may hope that with the satisfactory data he has provided, and with the daily increasing interest that is arising in the extension of Irrigation, the subject of the Sutlej Canal may ~~be~~ ere long be resumed with full vigor.

~~The above~~ [Such was completed] a rapid outline of the different projects ~~that had been under consideration~~ for Canals ~~making~~ in the North West provinces, the surveys of which had been conducted at the same time with those ~~for the Establishment~~ of a line of Canal for the irrigation of the Country between the Jumna and the Ganges, or of that line which is [especially] the subject of the present paper. —

I have before mentioned that the only attempts ~~that~~ [which] had been [in our time] made for the irrigation of the land lying on the right of the Ganges River,

River, ~~were those in which~~ [was when] Captain Debude ~~had~~ proposed to make use of the waters of the Hindun and West Kalli Nuddies, and by establishing Dams over their courses to obtain ~~a supply for irrigation for~~ [the means of irrigating] the Meerut Bolundshuhur and Allighur Districts the site of ~~Captain Debude's~~ [the proposal] works being ~~that of~~ [on] an ancient Canal ~~supposed to have been dug early in the 18th Century by a Native Chief by name~~ Muhummud Aboo Khan

> bearing the name of Muhammud Aboo Khan a native chief by whom it was supposed to have been dug early in the 18th Century.

Captain Debude's enquiries established the fact that the united volumes of the above mentioned two Rivers would not during the dry months provide a supply that would last longer than 180 days and that during the rainy months the works on the Rivers themselves would be subjected to the most extreme flood action. ~~From~~ [To] these sources therefore it was hopeless to look for ~~a supply sufficient to meet~~ [the means of meeting] the demands of any comprehensive scheme for irrigation. The Ganges River alone could, consequently be ~~looked to~~ [depended on]. Colonel John Colvin C.B. at that time Superintendent General of Canals, was satisfied that an examination of the River above and below Hurdwar would prove its efficiency for the purposes required; ~~both~~ Colonel Colvin's [views] and my own ~~views~~ coincided in the advisability of making early enquiries and subjecting that part of the khadir or low land lying between Hurdwar and the head of the East Kalli Nuddi to ~~examination~~ [careful survey]

~~communication~~ [carried survey]; the impracticable running out of this part of the Country, especially the depressed tract of land above alluded to, and the abrupt transition from high to low ~~land~~ levels in the neighborhood of Dowrassi, Noornuggur and Tookurtal, were certainly features by no means favorable to success, but it was determined to settle the question at the earliest opportunity possible.—

~~At the end of 1836~~ Colonel Colvin left India (at the end of 1836), giving over charge of his duties as Superintendent General of Canals to me; and it was in November of that year that the first series of levels was taken.

The Bungunga, an Old Branch of the Ganges River, is ~~situated with reference to~~ [in the same way] the Parent Stream, in the same way that the Boodhi Jumna is ~~situated with reference to~~ [with] the Jumna. The Head of the Boodhi Jumna is the Head of the Eastern Jumna Canal; it was supposed therefore, that the Bunguunga might ~~play the same part in connection with~~ [illegible] a Canal from the Ganges.—

The village of Budshahpoor which is close to the Bunguunga was ~~the~~ ~~[illegible]~~ [selected] as a favorable point from which to commence a series of levels ~~from~~, and the most desirable ~~point to~~ [illegible] ~~[illegible]~~ [to decide], was the difference of level between the water at that point, and the high land near the village of Rampoor ~~which~~ ~~was~~ the site of Captain Debude's Canal Head after he had raised the water by means of ~~[illegible]~~ Dams to a higher

of 30 feet from the end of the West Kalli nuddi. The results as will be seen from Diagram I were very unsatisfactory, and shewed that the point which had been taken up on the Bhagirutti was totally unfitted for the site of a head of supply. To try, therefore, a point higher up on the line of the Ganges, was the 2 method of overcoming the difficulty 1 that offered itself, as it be appeared that by taking a circuitous route the apparently impracticable line of country might be avoided. Colonel Colvin with whom I was in correspondence on the subject was sanguine that success would ultimately attend an examination having for its object the examination of the Country lying between these nuddies and the high and elevated land; it appeared to me that under such difficulties it was more than probable that the expenses attending upon a Canal would be too great to warrant the undertaking of the work, and it was not until some time afterwards when I had made myself acquainted with the nature of the tract, and examined the data which I had obtained in my Barometrical levels, and compared them with those of the Eastern Jumna Canal and the known Barometrical heights which connected the whole that I was able to form a proper estimate of the [illegible] of such a work. At the time, however, my occupations were of a nature that prevented me from continuing the enquiry and the question remained temporarily at rest.

The calamitous events of the year 1837-1838 and the extent of human

human misery ~~brought on~~ by ~~an~~ utter failure of the crops in the Central provinces, especially in the Lower Districts of the Doab, leading to famine in its most aggravated shape, and to incidents such as is unknown in Civilized Europe, are not even at the present day forgotten by those who at that time were resident in Upper India. The exertions of the European community in alleviating the sufferings of a starving population were carried on with true Anglo Saxon energy, and the sacrifice of a Million Sterling in Revenue, either in remission or in distributing food, was a guarantee of the interest that the Government felt in this frightful calamity.

As the famine was chiefly felt in the lower and central districts of the Doab, and as the evils had after all been only partially relieved by such an enormous sacrifice of Revenue, the ~~natural~~ question ~~suggested itself~~, as to what might have been the results ~~supposing that~~ a canal for Irrigation had been completed previously to this year of famine; had such a work been executed, the Government would in all probability have been saved this sacrifice of money, and in a moral point of view have been spared the distress of witnessing so much misery. – The project of making a canal from the Ganges so as to provide Irrigation to the Doab was, therefore, no longer to be considered a mere subject ~~of~~ of speculation but ~~to be put to the~~ test at the earliest possible period. – My views

~~the~~

~~on the subject~~ were explained to Lord Auckland who was at that time Governor General, with a recommendation that Government should authorize the disbursement of a few thousand Rupees for an examination of the Khadir to prove the practicability or not of overcoming the difficulties which were supposed to exist in that region. His Lordship having approved of this measure and having directed me to carry on the enquiry, I proceeded to Hurdwar and commenced operations early in the month of December 1839.

The design for carrying out these operations will be best explained by a diagram, and by ~~an~~ explana~~tion~~ of the data on which my views were founded —

DIAG: I.

The line of levels which had been taken by me in 1836 is shewn by the dotted line, it commenced from the surface of the water in the Banganga near the village of Badshahpoor which is situated 22 miles South of Hurdwar — From the point A the levels

levels ran for a distance of 40 miles (impinging on the head of the East Kalli Nuddi at **B** on the village of Untwarra marked in the above Dia-gram) to the point **C** on the West Kalli Nuddi, it was at the point **C** im-mediately under the village of Rampoor, that the head of Muhummud Aboo Khan's Canal was situated and where the Dam proposed by Captain Debude was to be built.

The following results were ob-tained from the above line of levels

The point **A**	83 feet	below	**D**
A	23 1/10 feet	below	**B**
A	12 66/100 feet	above	**C**
A	30 feet	below	the land

on which the village of Rampoor stands. In other words in a line of 40 Miles, or from the surface of the River near the village of Badshahpoor to the surface of the West Kalli Nuddi at Rampoor the fall is only 12 66/100 feet: and to the surface of the high land on which Rampoor stands there is an actual rise of 30 feet

From the point **A** to **D**, a distance of 10½ Miles, the land is almost entirely on one level for the distance of 9 Miles; at this point it rises suddenly until it gains an ele-vation of 83 feet near the village of Kumbhera at **D**; its slope on-wards towards Rampoor may be estimated at 2 3/10 feet per Mile.

The debouche of the Ganges into the plains lies at least 25 Miles lower on a latitudinal line than that of the Jumna. The Eastern Jumna Canal which leaves the Jumna at the point of debouche from the Hills, has opposite the town

of

Saharunpoor, which is on the same parallel as Hurdwar, is 300 feet of level; The Eastern Jumna Canal at the village of Bynswal, which is [illegible] ~~directly on the same parallel~~ as Behra, is 132 feet below Saharunpoor. Taking, therefore the known Barometrical heights of Hurdwar and Saharunpoor, and reducing the Canal levels accordingly, the following results were arrived at.

Saharunpoor	1013	Hurdwar	1024
Bynswal (on the Eastern Jumna Canal)	888	Behra	888?

Fall from Hurdwar to Behra feet 136

I assumed therefore, that the village of Behra was not very far different in Barometrical height to that of Bynswal, and that as by taking a circuitous route from Hurdwar to Behra which could hardly under any circumstances exceed 50 miles in length, the object of my survey was evidently attainable even were the land at Behra much more elevated than I had assumed it to be. The line of operations in the survey therefore, was sufficiently clear, it resolved itself into a simple examination of the ground between Hurdwar and the westerly portion of the Khadir both above and below Roorkee, and, to use the words of my original report to the Government, "the only "objections (supposing that my assumed height of Behra is correct) "to the project depend upon the state "of the Country's surface in that "direction; if a connected ridge can be

"be discovered only broken by the "escape of the Solani, this River "would I imagine offer no un- "conquerable impediment to a "Canal"

By taking my way along the country westward of Hurdwar, and embracing the westerly portion of the Khadir by circles of levels in numerous sweeps both above and below the true line upon which the Canal would take its course, this true line exhibited itself in two ~~courses~~ directions, the first, extending very much to the west by which the line of Canal bed would continue in soil; the second, a more direct line ~~by which~~ the valley of the Solani River ~~would be crossed~~ by an aqueduct. The first was a very [illegible] and ~~course~~ line, extending far to the west into the high [illegible] joining the heads of the Solani River, and thereby coming in contact with a great quantity of mountain drainage; the other ~~with a more direct course, but~~ avoiding the [illegible] and drainage round the [illegible] to be contended against, necessitated the crossing of the valley on high levels, and the construction of an aqueduct, the cost of which was great.

After completing the survey of the Khadir tract and satisfying myself of its being suited to the required purposes, I continued a series of levels both longitudinal and transverse to a point near Myapoor. I had during my stay at Hurdwar measured the discharge of the Ganges River, the supply of which in the months of

December and January

December and January was equal to 8000 Cubic feet per second, and therefore capable of providing for any demands that we might make upon it. I had in my progress down the country observed that material of all sorts could be procured without much difficulty; and it appeared to me that in submitting a project to Government it was desirable to produce one on a minimum scale, in which the cost of the works through the Khadir would be met by a sufficiently remunerating return on the Irrigation which lay below that tract; the Estimate in fact which I proposed to submit was intended to show the smallest amount at which a canal could be made with advantage; and having explained the facilities that existed both in material and in a supply of water, together with the means of carrying that supply over the difficulties of the Ganges Khadir, ~~to [illegible]~~ to the Government to determine whether by the construction of a larger and more spacious channel, the extent to which the water of the Ganges could be applied to irrigation in the Doab might not be taken the fullest advantage of.

My report and Estimate on the Ganges Khadir is dated 30th June 1840, the amount of the latter was Company's Rupees 10,00,113

The Supplemental report on the prolongation of the Canal down the Doab is dated 15th August 1840 and the Amount of the Estimate which accompanied it Co. 15,91,045

Total Compy's Rupees 25,91,158

The foregoing included 225 Miles of Main Canal, 73 Miles of Branch, and the necessary machinery for converting the main into a Navigable line.—

The return which was calculated on the average of that from the Irrigation Canals on the Jumna, was estimated at about 10 per cent on the outlay.

With reference to the abstraction from the Ganges ~~River~~ of large bodies of water, which ~~in taking full advantage of the means offered to us, we were in all probability on the point of putting into execution~~, it became an object at this period of the enquiry to establish gauges at different points on the River, and to ~~effect~~ as many measurements of discharge as opportunities offered. Water Gauges for measuring the rise and fall of the surface of the River were established at Hurdwar, Gurmookhteesur, Futtehgurh, Cawnpoor, and Allahabad. The registers of these Gauges with the exception of the two first which were intrusted to Native agency, were kept by the Engineers or Civil Officers of the Stations; The Hurdwar, Gurmookh-teesur and Allahabad Gauges, were discontinued in consequence of disarrangement by floods, and doubts as to the dependence to be placed on the records, but those at Futtehgurh and Cawnpoor which are to be found in the Atlas may be depended upon, and for the last 10 years will give a very accurate representation of the rise and fall of the Rivers surface

[illegible]

From a series of measurements for discharge taken by myself at a point on the Ganges just above Hurdwar, I calculated that the discharge which might be considered a Minimum at that point was equal to 8000 Cubic feet pr Second, an amount that did not differ in any great degree from that which was formerly given by Captain Herbert from measurements taken by him about 10 years before when he was employed on the Himalayan Survey.

At the Gurmooktesur Ghaut, a point situated below the Dingh a set of observations was made by Capt. A. D. Tennant Bengal Engin simultaneously with those at Hurdwar the time selected was early in March when the River is supposed to be at its lowest, and just before the melting of the Snow in the Mountains leads to a rise in the ~~River~~ surface. I ~~was in hopes~~ hoped by thus obtaining these measurements in March to obtain the Minimum discharge of the ~~Ganges~~ River, and the uniformity of the results of different ~~measurements~~ gave me confidence. ~~as to their correctness~~; These results ~~of these measurements~~ were as follows:-

		Discharge pr Second
Hurdwar	1st March 1842	= 7166·1891
Gurmooktesur	1st Do	= 8625·2194
	2nd Do	= 8883·195
	25th February 1842	= 8681·894

Gurmooktesur is situated 65 Miles South of Hurdwar, and the excess in volume at ~~that~~ the latter point is to be accounted for by the River having in its course received all the drainage

of

of the Khadir, including that from the Puttri, the Solani ~~and~~ its tributaries and the different lines ~~of drainage~~ both on the right and left ~~side~~ of the River. The results of the measurement at Hurdwar it will be observed shewed that in the driest season of the year, we might depend upon 7000 Cubic feet per second, and the Establishment of Gauges at different points down the course of the River would hereafter when a body of water had been abstracted for Canal purposes, shew the effects ~~upon the~~ of that abstraction on the surface level of the River ~~of the abstraction of that body~~.

The Government of India having been satisfied of the advantage that the high land of the Doab would derive from the introduction of Irrigation and being examined ~~having pass~~ the plans and surveys ~~acknowledged~~, the practicability of overcoming any Engineering difficulties that might occur in the Khadir; ~~submitted its recommendation~~ to the Court that the works should be designed on a scale capable of taking the fullest advantage of the supply available at Hurdwar. The Court in their Despatch dated 1st September 1841 recognise the importance that is attached to works for Irrigation and to their financial benefits and ~~but~~ observe that "apart from the consideration of financial results, "which we are far from contemplating "with indifference, there are few "measures connected with our

revenue

Revenue Administration in India, "more calculated to contribute to the "general improvement of the country, "the amelioration of the condition "of the people, and to raise the "character of the Government than "those of the nature now under our "consideration; we concur in opin-"ion with the Government of Agra "that a higher ground for advocating "these works is found in the security "which they afford against famine "and its attendant horrors" "Five "years" Mr Robertson remarks, "have scarcely passed since the "very country through which the "proposed Canal will be excavated, "was laid waste by a famine, which "cost the lives of thousands and "presented a scene of suffering still "fresh in the recollection of all classes; "to such another visitation the Canal "will afford a palliative if not a "remedy" "Influenced by these "considerations which are strengthened "by the observations contained in the "minute of the Governor General "dated 3rd April last, and relying "on the discretion of your Government "with reference to the period of com-"mencing and in carrying this "project into execution with due cau-"tion, and with a strict regard to "economy consistent with the im-"portance of the work, we have re-"solved to give our sanction to the "proposed undertaking on such a "scale as may be consistent with "safety to the works, and the accom-"plishment of the important objects "contemplated in their construction" On

On the receipt of the dispatch from which the above is an extract, a Committee consisting of Major Abbott of the Engineers as President, with Captain Baker of the Engineers and myself as members, was directed to proceed to the ground and report on the efficiency of the proposed works, the probable success of the undertaking, the scale on which it should in the first instance be carried on and the precise measures to be recommended for adoption; the letter conveying this order was dated Military Board Office 24th November 1841 and on the 7th of February following the Committee's report was submitted to the Government. I may remark here that the attention of the Committee had also been called to the following points: 1st the probable effects of the abstraction of the maximum supply of water on the navigation of the Ganges. 2ndly The probable cost of extending the Canal to Allahabad. 3rdly The probable return from the works. On the first of these points I shall have occasion to say hereafter, but in the meantime, the Committee when recommending the abstraction of 6750 cubic feet per second, or very nearly the whole river supply in the River ~~at the head~~ at Hurdwar during the driest months, came to the following conclusions, founded on the analogous example of the River Jumna, "during the months January and February of each year", the Committee remarks "The whole apparent supply is

diverted

"divided from its channel to feed
"the two Canals East and West,
"yet the under-current which per-
"colates the gravelly bed, together
"with the drainage of the inter-
"mediate country, provides a
"navigable stream of water at the
"station of [illegible], a distance of
"260 miles by the River's course,
"and the Committee infer from
"this example that in abstracting
"6,750 Cubic feet from the Ganges
"supply at Kunkhul, which during
"the dry season is estimated at
"8000 Cubic feet per Second, the
"navigation of this River will not
"be injured below Cawnpoor. Be-
"tween that point and [illegible]
"that the navigation for the larger
"classes of River craft will probably
"be impaired, if not altogether
"stopped, therefore it appears to the
"Committee to be absolutely neces-
"sary that the main line of Canal
"from Kunkhul to Cawnpoor should
"be rendered completely efficient
"for navigation."

The Committee considered that it was in every way desirable to provide Irrigation in the whole of the lands lying between the Hindun and Ganges Rivers, and that this should be combined with navigation; to effect these objects it would be necessary to use 6750 Cubic feet per second of supply. This supply the Committee observe "will be ample to carry one main Line of navigable Canal from Kunkhul to Cawnpoor, and to supply irrigation to the whole district bounded by the Ganges on the one side and by the Hindun and the

Jumna

[illegible]

The [illegible] line [illegible] Aqueduct (the Aqueduct [illegible] [illegible] in Instalments in the [illegible] [illegible]) was prepared and recommended by the Committee, after a careful investigation of the ground, especially of that on the circuitous route, over which a levelling Instrument was passed; the preference to the Aqueduct line was ~~determined~~ given in [illegible], [illegible] the many difficulties which attended the other in crossing numerous lines of drainage by Dams constructed across the sandy beds of Rivers to [illegible] [illegible]; Estimates, however, were submitted for both lines, and the following abstract of the [illegible] to either one or the other to the judgment of the Government.

<u>On Aqueduct line</u>

Cost of works in the [illegible] up	
to the Town of [illegible]	167635
Cost of works from [illegible] to [illegible]	170123.0
Do. [illegible] Branch	62254.0
Do. [illegible] do	18454.0
Do. [illegible] do	67714.0
Do. [illegible] do	29158.0
[illegible] contingencies	31739.1
Total Cost [illegible]	666529.6
Cost [illegible] [illegible]	
[illegible] [illegible]	56118.0
Grand Total Cost of Aqueduct line Rs	722640.6

<u>Circuitous line without Aqueduct</u>

Cost of works in the [illegible] Rs	1188335.12.1
Do. from [illegible]	
[illegible], including	
Branches as before	1476921.0
[illegible] contingencies	283262.12.6
Grand Total Cost without Aqueduct	5948518.10.8

From

June The investigations of the Committee on the subject of returns ~~with the~~ ~~[illegible]~~ it was calculated that Irrigation would be provided for 2303 Square Miles, the return upon which at the average rate of 10 annas pr Beega would be equal to $\frac{2303 \times 1024 \times 10}{16} = 1486420$ Rupees, independently of the collections for Mill rent, transit duties, and the miscellaneous sales of Canal produce. –

On closing their report the Committee recommended that no time should be lost in commencing the Manufacture of Bricks at those points, which are common to both the straight and circuitous line, and that Captain Cautley should be permitted to commence along the Main Trunk from Roorkee onwards to Hurdwar, completing all the masonry heads of Branches, and excavating such portions of the Branches themselves, as the Executive Officers may find it in their power to undertake.

It was also recommended that a staff of 3 Executive Officers, 6 Assistant Executives, and twelve Overseers should be placed at Captain Cautley's disposal.

During the whole of the period ~~through which the circumstances~~ above ~~narrated occurred~~, Mr. T. C. Robertson who was holding the reins of the Government of the North Western Provinces, and who from his appreciation of the value of the Jumna Canals, looked with extraordinary interest and favor ~~to~~ on the Ganges Canal project, exerted every energy to break ground, and to

advance

advance the progress of the works.— The time, however, was that of our ~~Affghan disasters which, with a change of administration in the head of the Supreme Government, were sufficient, perhaps, to account for a want of sympathy for requiring the aid of Assistant Engineers, left me to carry on the works as well as I could without it~~.—

On the 25th February 1842 orders were issued by the Agra Government for the commencement of the work on the terms of the Committee's recommendation, and on the 16th April following ground was broken in the neighbourhood of Hurdwar in commencement of the excavation of the Channel.— At the same period also Brickmaking was ~~established~~ started at different points on the line under the Supervision of Mr Wright, an Uncovenanted Officer who was under my orders on the Eastern Jumna Canals. At this period also Lieutenant Turnbull of the Engineers was detached by me from the Eastern Jumna Canal works, to commence operations on the high land from Roorkee downwards, so that with the means at our disposal we had in the month of July 1842, lined out nearly One hundred miles, collected a large quantity of materials, and had excavation in full progress at three different points.—

As far back as May ^last year^ some doubts had been expressed by the Supreme Government as to the propriety of proceeding with the works, and various reasons were alleged for entertaining this view ~~of the question~~;— My Application in

in act, or Staff had been met in a
desire to suspend, for the present, [the
arrangements and appointments
which I had recommended, ~~in~~
~~consequence of~~ [on] financial and other
considerations]. The collection of
material and excavation however,
were allowed to proceed, until the
month of July, when the Supreme
Government in a letter dated 21st of
June 1842 to the address of Mr Hamilton
the Secretary to Government N.W.P.
in directing all the works to be
stopped, called for statements of
expenditure up to the time of
closing the works with a report
upon their present state ~~[illegible]~~
~~up to that period~~. My report
which accompanied these state
ments was dated — August 1842.
It referred to a letter ~~from~~ addressed to the Military Board by Colonel
Stuart, Military Secretary to the
Government with the Governor General,
dated, Allahabad 30th June 1842
(13 days after ~~[illegible]~~ the letter from the Supreme Govt
to Mr Hamilton just alluded to above had been written)
~~and addressed to the Military Board~~;
by which it appeared that the intentions of the Governor General had been modified, and that it was now his wish ~~the wish of the Governor~~ General
that the works should be ~~carried on~~
on the principle established in
Mr Hamiltons letter No 680 of the
17th June 1842; ~~in this report~~ accordingly I
stated in my report that in consequence of having
received the Military Board's orders
conveying those of the Government
dated 30th June "I had directed
"the daily parties to be again
"entertained; at the same time
"it would relieve me from much
"anxiety if Government would at
"once place a limit on my Annual
"Expenditure which will enable me

to

"to work satisfactorily under the "conviction that I am strictly "agreeably to the wishes of Govern"ment". — I observed that a "lakh & two of Rupees per annum "would enable me to carry on work "very steadily with the small Estab"lishment at my command; both "brickmakers could be entertained, "and about 50 or 100 Earth contractors "might be kept in employment; "if only half a lakh, or even a smaller "sum was allowed I can regulate "my expenditure accordingly."

The statement that accompanied my report above alluded to, showed that up to the 1st July 1842, the actual expenditure and liabilities had amounted to Rupees 1381[illegible] . 0 . 3.

The Supreme Government in the Public Department Secretary's letter No 36, dated 17th September 1842, ~~and~~ in reply ~~to~~ to the above report ordered. "In compliance "with Captain Cautley's wishes, "and for the purpose of obviating "any misconception of the wishes "of Government the Governor General "is pleased until further orders to "restrict the annual expenditure "on the Ganges Canal, salaries and "Establishments included, to two "lakhs of Rupees". —

The above precis of correspondence which took place will throw some light on the interruptions which were experienced in ~~the~~ the early days of our works; a variety of difficulties had been urged by parties, and these difficulties had been answered, an error in my original report ~~to~~ due to the omission of a decimal point by which the proportion of surface

of

of the Doab which would derive benefit from the Canal, was much exaggerated, was brought forward; and it is possible that this error had some influence on the indecision which the above correspondence exhibits. The error was undoubtedly an unfortunate one, but it vitiated none of the calculations on which the merits of the project were based ~~and as such required little explanation~~. The probable effects of Earthquakes were brought forward as ~~opposed~~ to the construction of the Solani aqueduct. The destruction to the navigation of the Ganges was urged as a sufficient cause for not proceeding with the works. The effects in a sanatory point of view upon the Districts which compose the main lands of the Doab by introducing miasma were urged with a perseverance ~~worthy of a better cause~~. The works however had proceeded too far to be violently stopped, and under the restrictions pointed out above they proceeded steadily, with the cordial support ~~full patronage~~ of the local Government, but with little countenance from other quarters. —

The duties and responsibilities had been progressively extending, the Executive duties of the canals in the Deyra Doon had been added to those of my specific appointment as Superintendent of the Eastern Jumna Canals; in addition I had at this period the whole of the responsibilities of the Ganges Canal works and its expenditure.

The Supreme Government in the month of July 1843 placed me in independent control of the Canals

[Margin note:] This was immediately and fully explained especially by the Military Board in their Letter No. [illegible], dated 17th August 1842 to the Govt of [illegible] [illegible] was [illegible]

[Margin note:] scarcely justified by the information at command.

Canal to the Doab relieving me from Executive duties; and on the 21st February 1843, I had the satisfaction of obtaining the services of Lieutenant Richard Strachey of the Corps of Engineers, for the Executive duties of the Ganges Canal. No additional expenditure to the Lakhs already granted, however, was authorized, and the Gwalior Campaign which took place at the end of 1843, still further reduced the chances of obtaining aid from the Government, and still further destroyed the hopes that I had at one time entertained of being permitted to push the works on with progressive vigour.

At the period of my giving over charge of the Executive duties to Lieutenant Strachey the amount of Expenditure was thus:

Excavation Rupees	73,[illegible]
Materials and Sundries	3[illegible],[illegible]80 [illegible]
Total Expended up to [illegible] 1843	Rs 110758.[illegible]

Early in the cold weather of 1843/44 the levels of the Doab which ~~lost~~ in my Survey of 1839/40, ~~[illegible]~~ had been completed only in ~~at~~ Mynpoorie, were pushed forward to Cawnpoor and Allahabad, and the whole of the cold season of 1843/44 was passed in ~~completing~~ completing the levels and reconnoissance of the Country. The completion of this Survey enabled me to draw up a full report and Estimates of the Canal Works; this was submitted to Government, and was dated 19th February 1845.—

Before entering into a detail of this report I must observe that previously to my undertaking the Survey above alluded to, the Supreme

Supreme Government had decided that a total modification of the original design should take place, and to use the words of the Minute to which my attention was directed "it should be in the first instance "a Canal of Navigation, and all "the water not required for that "purpose may be distributed "for the purposes of Irrigation." The main Trunk in short was now directed upon Allahabad, to that point where the Steamers now ascend the River: the original Project, therefore, of the Navigable line, was carried merely to Cawnpore having merged into one of considerably greater length, and (as connected with Irrigation) into one leading to much greater difficulties. I submitted three projects which will be explained hereafter, noting at the time that I had endeavoured so far as was in my power not to lose sight of the purposes for which this Canal was originally projected, and to provide means of Irrigation as extended as the security for navigation to Allahabad would admit of.

With these views I placed before the Government Three projects with Estimates of the Cost of each appended to them.

The 1st Project was one wherein the main line had a declivity of bed varying from 6 to 12 inches per mile, with Falls and Locks attached, to overcome the superfluous slope of the Northern District and with works of ascent and descent into the Jumna River at Allahabad. Efficient means were provided in this project for ~~Irrigation on the~~

~~Main~~

~~[illegible]~~ as far as the boundary of the Cawnpoor and Futtehpoor District in advance of which they were somewhat interfered with by the depth of the Excavated channel.–

In addition to the main line, the following Branches for Irrigation were proposed

Futtehgurh Branch	160	miles in length	
Bolundshur	Do	70	do
Etawah	Do	172	do
Cawnpoor	Do	43½	do

This line is an artificial River constructed on the same principles as the Canals now existing in the North western Provinces.–

The total Amount of the Estimate on ~~the~~ project No 1. was Rs 10236643.14.11

The 2nd Project differed from the 1st in continuing the main line from the boundary of the Cawnpoor and Futtehpoor District to Allahabad, by a System of Reservoirs with Locks to the Jumna, and extending the Cawnpoor line of Irrigation to the neighborhood of the Town of Cawnpoor, the tail water ~~falling~~ being discharged into a Ravine or tributary connected with the Pandoo River near that place, ~~or where such convenient, by using the water in Irrigation by a water Course leasing, before a [illegible]~~ or if such disposal was more [illegible] by using it as the means of supply an irrigation channel bearing to the point where the Pandoo unites with the Ganges River.

The total Amount of Estimate on this 2nd Project – was Rs 07,03558.2.9

The 3rd Project differed from the 1st in continuing the Navigable line

line from the boundary of the Cawnpoor and Futtehpoor districts to the Jumna near the Town of Saar, turning ^southerly^ to the south and connecting the canal with the Jumna at a point opposite the junction of the Hamirpur ~~the~~ ^river^ Canal which ~~[illegible]~~ for the last 80 miles ^had^ run contiguous and parallel to the Pandoo River ~~[illegible]~~ ^and^ in fact ~~[illegible]~~ ^have^ maintained a close proximity to that ~~[illegible]~~ ^river^ until it goes into the Jumna. The Cawnpoor line ^was^ ^to^ be navigable and locked into the Ganges with a branch for Irrigation towards the junction ^of the^ ^Pandoo^ ~~[illegible]~~.

The total Amount of the Estimate for this No 3 project was 3,30,746.12.6

It was evident that to carry out any of these modified plans, which are of a much more extensive nature than those originally contemplated would be found necessary. The determination to make ~~[illegible]~~ the main line navigable to Allahabad instead of to Cawnpoor, led not only to an increase of length to the excavated Channel, but the flatness of the Country through the Districts of Futtehpoor and of Allahabad ~~made it~~ ^rendered it^ necessary to reduce the declivity of bed for the last 153 miles to 1½ inches per mile, ^and thereby causing^ ~~leading to a great increase in~~ the area of the excavated Channel ^so as^ to effect a discharge of the calculated volume of water. ~~[illegible]~~ ^With^ such a length of navigable Channel it was found convenient to straighten the Course of the Canal between Nanoun and Mynpoori, thereby

bringing

bringing the cumulated fall between those points on a much shorter distance; the necessity of additional arrangements for disposing of this surplus slope was obvious~~ly evident~~; another masonry [illegible] therefore, was projected at Boodpoor in the Suharunpoor District, and clearing out the tail of which in the ~~additional~~ excavation was ~~necessary~~ required; Drainage works in the shape of Aqueducts, and means of crossing Rivers, which were not anticipated by the Committee were included in the present Estimates, and in proposing means for the further cleaning the [illegible] of the works, ~~were~~ materially increased. In all these projects it may be remarked that the efficient drainage of the Country through which the Canal passed, have been one of the leading points of inquiry, it had in a great measure influenced the direction in which the Canal had been carried, and had on all occasions been considered as one of the first points for investigation.

The above Estimates were framed on the [illegible] Solani River in the Ganges Khadir ~~being~~ which passed by an aqueduct. My report however in including the reduced ~~cost~~ e[illegible] that ~~would be incurred by adopting the~~ Circuitous route, placed it in the power of the Government to make its own selection. In ~~submitting these Estimates for the circuitous line I remarked, that although the profile was in every way adapted to the purpose of the Canal, and although the original cost is much less, the~~

~~numerous~~

Submitting [illegible] Estimates [illegible] that the [illegible] the circuitous [illegible] of the Canal, [illegible] original cost [illegible] of the [illegible]
I drew attention however to the fact the numerous [illegible] the [illegible] the Canal [illegible]

numerous ravines, rivers and other drainage with which the line would have come in contact, were not only very serious objections in the first instance, but the continuance of annual repairs and maintenance of the embankments on such an extended line, intersected in its whole course by rivers and nullahs, renders it doubtful whether as a mere matter of economy the circuitous was preferable to the more direct route; considerations, however, independently of the above, arose as to the wild and uninhabited state of the country through which the circuitous line took its course, want of supplies would always be an inconvenience, and when to these are added the extensive inundations that would be formed at the head of each dam in dependance of the Eastern embankments, the difficulties of communication, inconvenience of inspection, and without doubt the unhealthiness of the country itself, with the fact that, from the position of all these works, so much higher up the course of the rivers, the declivity of their beds upon which the dams must be constructed, would be much increased and the evils arising therefrom equally augmented, the voice of the Committee was unanimous in preferring the direct line by Bajoohri and Mahewur with ~~the Aqueduct, to the more circuitous route by which the Aqueduct would be avoided~~

The Estimates for the three projects above described based on the adoption of the circuitous route

in

in the Khadir were as follows: –

No. 1	Project	Costs	Co.Rs 26,96,695.12.4
2	do	"	18,63,610.6.2
3	do	"	16,29,798.9.11

By taking this ~~circuitous~~ line and avoiding that of the aqueduct, a saving would be effected of Co.Rupees 10,66,948..3..7, or upwards of Ten Lakhs. –

Previously, however, to the submission of the Estimates above described, considerable changes had taken place in the administration of the Country; Mr Thomason (who had succeeded Mr Robertson in the Government of the North Western Provinces and ~~who had~~ in the fullest appreciation of all projects in the improvement of the Country had during his administration not only his countenance ~~to the project on the~~ Ganges Canal, but all the aid that he was able to bestow upon it) had resigned his seat to Mr Thomason, ~~[illegible]~~ Secretary to Mr Robertson. ~~and~~ Mr Thomason in the early days of his career was given his deepest attention to the subject of the Canal, to the influence that it was likely to exert upon the welfare of the Country, and to urging on by every means in his power the better movements to facilitate its completion. In the middle of 1844, Lord Ellenborough was replaced by Sir Henry Hardinge, who as Governor General reached Calcutta and assumed the reins of Government in the month of July 1844.

At this period my health which after 26 years of Indian service had been gradually failing

determined

determined me to proceed to Europe, and early in February 1845, I left the North Western Provinces, having made over charge of the Ganges Canal works to Major W. E. Baker of the Bengal Engineers

Chapter II
State of the works at the period … the
… Major W. E. Baker
… 1845 to 1848

The state of the works at the period to which I have alluded in the last para, the ~~traditional to the~~ corresponded with the Amount of Annual Expenditure that had been accorded to us by the Supreme Government; Bricks had been burnt and collected at numerous points on the line from Hurdwar to ~~the boundary~~ below Meerut and Boolundshuhur; Masonry work had been commenced on a small scale ~~at~~ in the Dam and Regulator at Myapoor, ~~the site of~~ the commencement of the Excavated Channel above Kunkul; Workshops had been built at Roorkee, Police posts had been established at Myapoor, Roorkee and Munglour, and a considerable portion of the Channel between Myapoor and the Town of Jowallapoor had been roughly excavated; Excavation had also been commenced upon on the high land of the Doab near Munglour, and Lining out had been completed to about 100 miles South of that place

When I delivered over charge to Major Baker the amount of Annual expenditure to which we were limited was two Lakhs of Rupees. For the management of this expenditure there were two Executive Officers, Lieuts. Tracey

And

and Turnbull of the Engineers, and two Uncovenanted Assistants, Mr Wright and Mr Read, to assist them.

War and its consequences on the improvement of the country and the progress of works of public utility, appeared to be perpetually the rock upon which the advancement of these works was to be wrecked. It may be said that [the Ganges] originating as it did during the commencement of the Afghan war, ~~it~~ was nursed at a period of intense trouble to the state; its weary progress was unwillingly prosecuted during the whole of a warlike administration, in which the return of the Armies from Afghanistan, and fierce battles with the Mahratta chiefs were the ~~events~~ most remarkable [events]. The early part of the succeeding administration [illegible] ~~[illegible]~~ as it was ~~with~~ [by] the Sikh invasion, and the consequent demands ~~[illegible] the resources of the Country in two~~ ~~[illegible] heavy drains~~ on the public treasury; ~~[illegible]~~ [illegible] still further tended to impede the progress of the canal; Major Baker and his two Engineer Assistants in joining the Army which was concentrated on the Western frontier had, in act, by their departure, virtually put a stop to all active progress excepting that of continuing Contracts which had already been entered into, and it was not until the close of the war, and on the return of these officers to their respective duties that the subject of the Ganges Canal Works was allowed again to occupy the attention of the Government...

E.

In the interviews that I had with Lord Hardinge previously to my departure from Calcutta in 1845, I had obtained from him details upon the especial points which had influenced parties in their objections to the project; these resolved themselves into the injury that would be caused to the Ganges as a navigable River by the abstraction of water for the Canal supply, and to the probable effects upon the high land of the Doab by the introduction of malaria from Irrigation. As these were the two leading points, and as the first had for the present at least been disposed of; the malaria question ~~appear to resolve itself into one,~~ ~~which would~~ was naturally one ~~all under~~ for ~~a medical~~ special sanitary inquiry. For this purpose a Committee was assembled in November 1845, and on the submission of ~~the~~ its report in 1847* the whole question of the Ganges Canal ~~works~~ was brought under the notice of Government. In March 1847, the Governor General visited Roorkee and the site of the

* The Committee which commenced its operations on the 30th November 1845, and had proceeded through the Irrigation Districts of the Canals West of the Jumna as far as Hissar, was broken up at that stage owing to a call for the purpose of its members joining the Army of the Sutlej. On the 1st of November 1846 the Committee resumed its labours and completed ~~their~~ its investigations. ~~Their~~ Its Report which was dated 3rd March 1847 was presented to the Governor General on his visit to Roorkee.

Of this Committee, Major Baker of the Bengal Engineers, was President, and Dr Dempster of the Bengal Medical Staff, with Lieut. H. Yule of the Bengal Engineers, were members

the proposed works in the Ganges Khadir, and it was on this basis that the vigorous prosecution of the ~~works~~ irrigation was determined on. During this period my sojourn in England brought me to ~~connection~~ contact with those whose views on the Navigation and Sanitary questions led them to doubt the policy of continuing the Canal at all. As these Questions had considerable influence in retarding the progress towards the project, I will here interrupt the thread of my narrative by explaining the views them that had been adopted by myself and others who were advocates for the establishment of the Ganges Canal ~~works~~. I will take up the Questions as they were argued, beginning with that on Navigation, or, "on the probable effects "to the Ganges as a line of Navi"gation to Allahabad, arising "from the abstraction of 6750 "cubic feet per second from the "volume at Hurdwar." The arguments which were used by me may be thus explained.

The discharge of the Ganges at Hurdwar, during the driest season of the year, or that previous ~~to~~ to the melting of the snow in the mountains is calculated at about 8000 cubic feet per second, if, then, we, at this period, we remove for the purposes of the Canal 6750 cubic feet per second, it appears that we leave only 1250 for the supply of the River.

There is a peculiar feature attendant on the tract of country lying at the foot of the Sewalik hills as connected with springs, that

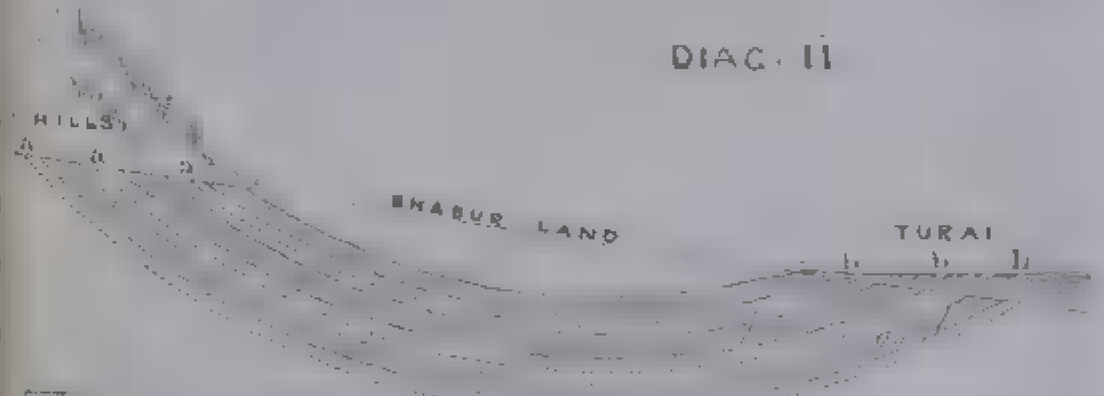
that is well known in the Rohilkund territory, and is also observable through the Doab and ~~the~~ west of the Jumna. In the immediate vicinity of the passes, and at the foot of the hills, spring water rises to the surface, sometimes exhibiting itself in small pools, at other times in small streams and rills, which flow for a short distance and then disappear in the sand and shingle of the rivers; parallel to and south of this line is a belt varying from 5 to 10 miles in breadth in which water can only be reached at extreme and in some cases at unmanageable depths; in advance of this dry tract the springs rise to ~~[illegible]~~ the surface, forming in Rohilkund ~~[illegible]~~ the unhealthy tract called the Turai, ~~where the springs flow on the surface,~~ in the Doab shewing themselves principally in the shallowness of the wells, although

[illegible]

on the southern angle of that part of the Ganges Khadir with which the Canal works are connected the ~~action of the springs upon the surface in forming~~ [illegible] extensive sheets and marshes [illegible] ~~[illegible]~~ to that of the Rohilkund Turai. The cause of this ~~apparent~~ peculiarity is, that in the whole of the tract skirting the mountains, there is a deep seated impervious stratum rising near the foot of the hills and cropping out on the Turai belt. That the water passing down the rivers percolates through the shingle and passing under this impervious stratum rises again to the surface at a considerable distance, leaving the intermediate space dry. The following

following section is explanatory of the views that I hold as to the springs above alluded to.

DIAG. II



Impervious Stratum
Line of Springs
a a a Points of Percolation
b b b Spring Heads.

It is to be inferred, therefore, that the establishment of Bunds or Embankments across the beds of Rivers (of which the Ganges and the Jumna are the two principal ones) ~~subject to the influence of~~ these phenomena, at any point between a and b, or on that marked as Bhabur land, would only diminish the supply to a certain extent, and not as would naturally be supposed remove it entirely.

It is unnecessary to describe the relative positions of the Ganges and Jumna, as these are seen in the maps which accompany this paper; but these two Rivers pass through a country ~~[illegible]~~ possessing the above peculiarities, similar in its geological features, and evidently liable to the same action of Springs by percolation.—

On the results that the abstraction of the water, in the Delhi and Doab Canals have produced upon the Jumna River at a point opposite Agra, we may obtain an approximation to effects from similar causes, which may arise on the Ganges ~~River~~ at Cawnpoor and

Allahabad

and Allahabad

On Jumna at the debouchure from the Sewaliks has a discharge [illegible] equal to 4000 cubic feet during the dry months it occasionally happens that the whole of this water disappears at a point below the canal heads it is partly taken off by lateral cuts into the Dehli Canal on the west, and into the Doab Canal on the East, strong bunds being thrown across the bed of the River to effect this, and the portion which is not admitted into the canal cuts soaks unobservably through the shingle bed; South or on the down stream side of these bunds the bed of the Jumna has sometimes been laid perfectly dry, and to a distance of some miles south no appearance of springs of any description has existed; long before the River has reached the latitude of Saharunpore however water again appears, and although fordable at certain points boats are required at all the Ghats and ferries for the transport of merchandise. Opposite Agra the River is so far navigable that boats varying from 500 to 1000 maunds (or 18 to 36 Tons) laden with cotton, leave that place for the lower provinces, and as far as I could discover from enquiry amongst the boat people, the difficulty that they experienced was not in the neighborhood of Agra but immediately above the junction of the Chumbul where the Jumna forms itself into a shallow rapid, and during the dry months offers an impediment although not an insurmountable one to the passage of Craft. —

The

The average transverse section of the Jumna opposite Agra during the driest months may be estimated at 900 superficial feet, that is to say, the breadth is 300, and the hydraulic mean depth is 3 feet, the slope of the River is about 1·25 feet per mile: the discharge, therefore, on the formula which I have universally adopted in all my calculations is* 2061 cubic feet per second.

Between the canal heads (immediately south of which the bed of the Jumna is perfectly dry) and the Town of Agra the Hindun River is the only tributary that provides any additional water, and during the dry weather the maximum supply from this source was not beyond 80 cubic feet per second; neither the Delhi nor the Doab Canals pass off escape water to any amount worthy of consideration: it appears therefore that in the face of the abstraction of the whole apparent supply of the River from the [illegible] tracts at the canal heads, the Jumna ~~[illegible]~~ opposite the City of Agra still maintains the character of a River navigable to a certain extent, and carries a volume of water the origin of which can only be explained by springs and percolation.

Between Allahabad and [illegible] Allahabad or Cawnpore on the Ganges ~~[illegible]~~, there are the following tributaries:—

Main

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* R = 35·29
b = 422
V = 2·20 ft per second
D = 2061 cubic feet per second

Kali and Bhat nuddies and drain tracts of the Ganges Khadir
East Kali nuddi
Yar Woofadar
Ram Gunga
Eesun

are giving a perennial supply to the main Stream; the system of percolation which is so manifestly conspicuous on the Jumna may ~~[illegible]~~ equally [illegible] ~~[illegible]~~ in a wide placed in its neighbourhood, and flowing over a Country similar in Geological character. The extent of Percolation (if percolation is admitted at all) will it is presumed bear the same ratio to the original volume on the Ganges as it holds ~~it is shown to have taken place~~ in the parallel case of the Jumna. Should this be acceded to, we have the following results (laying aside the supplies of tributaries and assuming that the Ganges Canal absorbs the whole volume of the Ganges as the Jumna Canal does that of the Jumna)

*

As 4000 : 1861 :: 8000 : 3722 cubic feet per second; that is to say, that independently of the supply [illegible] ~~that~~ the Ganges ~~[illegible]~~ in its course from the [illegible] above noted, the volume of water which would pass Cawnpoor [illegible] ~~supposition that the Canal [illegible] the River [illegible]~~ ~~[illegible]~~ would be 3722 Cubic feet per second! In short that the Ganges River at Cawnpoor would when the Canal was in full vigor still

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* 1861 = 2061 − 200 cubic feet: 200 cubic feet per second being the equivalent supply received by the Hindun River between the Khatouli and Agra —

still possess a volume of water nearly as large as that of the Jumna, before the Canals in that River were constructed.

The conclusions at which I arrived from the above investigations tended to shew that little or no interruption would arise to the navigation of the Ganges as high up as Futtighur, and supposing that the whole body of the River as it leaves the hills was taken to the supply of the Ganges Canal. North and above Futtighur the demands for navigation are trifling, and the few boats which pass up to Gurmookhteesur and Sookertal (the latter being the most Northerly point to which boats reach) would readily be accommodated in the Canal itself with very inconsiderable inconvenience as regards the carriage of goods to the large towns and Cantonments to the South. Moreover that were the canal to be ~~established as~~ adopted a navigable line from the Jumna upwards, it would be preferable to the main Ganges, ~~and the [illegible] which would arise of the Ganges River being rendered a deterioration as a Navigable line from Hurdwar to Cawnpoor or Allahabad would be compensated for~~ and thus compensate fully for the evils it might cause to the river itself by the additional water for traffic which it would supply. As to the ~~question of the~~ Ganges being affected below Allahabad i.e. below the junction of the Jumna, the question was one of equal importance, but it was one upon which we had no sufficient data to guide us; the maps of India with the configuration of the drain-

-age

-rage of the Gangetic valley, and the proportion borne by the line under discussion, to that of the numerous tributaries etc. draining from the Himalayas to the Bay of Bengal, appeared to ~~be~~ justify the fears of those who anticipated no injury to navigation..

The whole question was an intricate one; nobody ~~attempted~~ ~~to doubt~~ denied that the abstraction even of the smallest possible quantity of water affected to a certain degree the navigation of the Ganges. But the effects were merely ~~trivial~~ nominal, and the ~~advantages~~ general results of the enquiry ~~state~~ appeared to resolve themselves into this:
"Were the evils to navigation of "a nature so ruinous as to "counterbalance the benefits "arising from the Canal?"

To those who considered that the navigation of the Ganges would not be interfered with by the Ganges Canal, the analogous position of the Canals on the Jumna, and the effects they ~~noticed~~ produced in that River, were peculiarly conclusive and satisfactory; a question in fact which might have been otherwise perplexing, was it not reduced to a very simple one, rendered comparatively easy.

The Jumna being a smaller stream than ~~that of~~ the Ganges was more dependent on the Land heads for its supply; the Canals on the Jumna abstracted at certain seasons of the year, and at periods when the navigation of the Jumna was least able to afford it, the whole available volume; a great part

part of the volume, passed off to the westward towards Hansi and Hissar, and whether by means of percolation or evaporation was entirely lost to the present view: and for the greater portion of its course the Hindun, which affords a supply of little or no consideration, is the only tributary. On its banks are situated the large towns of Delhi, Muttra, Agra, Etawah and Kalpi, to which the Jumna ~~[illegible]~~ affords the only means of water carriage for all the rich and extensive districts that lie on its banks; if, therefore, under these circumstances the Jumna Canals have a direct tendency to destroy the navigation, the navigation that would continue to be of the greatest importance and value; how should the Ganges River [illegible] which is less ~~dependent on~~ the ~~[illegible]~~ canal works [illegible] ~~[illegible]~~ ~~[illegible]~~? The Ganges canal in the first place does not take away the whole of the supply from the Ganges, there are numerous tributaries and feeders scattered along the whole course of the river; the irrigation from the canal is confined to the Doab region, and whether it escapes into the Jumna or the Ganges, is equally available for the purposes of navigation; the absence of all large towns on the right bank of the Ganges that are unconnected with the banks of the Ganges, as far south as Allahabad, with the known fact that the tributaries on that side are imperfectly navigable, reduces to

some

some extent the value of the Ganges as a navigable line to that particular region; the navigation of the Jumna on the contrary appears to be of importance to many large towns which lie on the right bank unconnected with the Canals, to all of which the River provides water carriage. The inferences are that the abstraction of water from the Ganges at the Hurdwar will be of less importance to ~~the Canals~~ that River, than the abstraction of water in the Jumna Canals is to the Jumna, and [illegible] that whilst the latter is providing the means of water carriage to some of the most rich, and, in a commercial point of view, most valuable provinces of the North West which lie on its banks, and whilst the Canals which are taken from it, are the source of great wealth and prosperity to the tracts that come under their influence; [illegible] the philosophy of denying advantages of a similar nature to the Ganges ~~[illegible]~~ which it is proposed to place under the same regimen is somewhat questionable. -

From the Month of April to the Month of December, when the Rivers are either affected by the melting of the snow in the Himalayas, or by the periodical rains, the abstraction of water for Canal purposes, has less influence than it has in the remaining months; during those of the rains, when the greatest part of the traffic of the Country is transported by

by water carriage, no sensible effect is produced on the Canals at all and it is only during the months of January, February and March, when the supply taken for the Canals bears the greatest proportion to the volume of the River, that the ~~effect upon~~ depression of surface level ~~the stream~~ is appreciable; & during this period, as well as during the other months, which are entirely free from the Canals or their effects, the navigation of both the Jumna and Ganges is confined to their own beds, the tributaries at this period having no pretensions to being navigable ~~rivers~~; the highest points to which boats ascend on the Jumna during this period being Agra and Muttra; & on the Ganges, Gurmooktesur and [illegible]. The size of the cotton boats which reach Agra gives the tonnage of boats on the two Rivers in those of the Jumna, and these cotton boats to which I refer reach Agra at periods when the whole of the supply of the River is derived from percolation. In the foregoing paragraphs I have attempted to show that the Jumna suffers, from the abstraction of water on the Canals, to a much greater degree than the Ganges will suffer, and that, therefore, there is every probability of the latter being more favorably placed with regard to navigation than the former.

Whatever may be said as to the effect of the Jumna Canals on the parent River, the fact is a notorious one, and one of which any ~~[illegible]~~ resident in these provinces might convince himself, that the

Jumna

Jumna during the whole year continues to be the line of water Carriage of a large and flourishing trade, the best exemplification of which is in the fleets of boats, many of them Cotton boats of large tonnage which are to be seen passing up & down ~~[illegible]~~ between the Towns of Allahabad and ~~[illegible]~~ Agra.

It is, however, solely in the distribution of the volume that the water which (under the worst circumstances of Canal interruption) passes down the course of the Jumna and Ganges Rivers in their approach to Allahabad can be said to be insufficient for navigation! The evil arising from distribution would in consequence of the excess of breadth in the bed of the Ganges than itself in all probability under all more exaggerated circumstances in that river than those done ~~[illegible]~~ in the Jumna, and shallows rendering navigation difficult, or even in some cases impracticable ~~[illegible]~~, might be the result of any such reduction of the volume of the River, but artificial means which lead to the evil, are at hand to remedy it, and the process of deepening Channels in wide sandy beds is one so well understood in India, and can be effected with such moderate means, and at so small a cost, that the injury to the navigation arising from this circumstance is one happily of no serious moment. As long as there is a body of water in the bed of a River sufficient, if properly distributed, to insure ~~[illegible]~~ navigation, it is the fault of the Government or of those concerned, if there is

no

no navigation, to raise objections to the abstraction of water for Canal purposes, when these purposes are acknowledged ~~in an economical~~ ~~to~~ to be conducive to the prosperity of the Country, to the increased wealth of the Inhabitants and consequently to the improvement of the Revenue; and when such abstraction leaves an ample supply in the River for all purposes of navigation, which supply is properly ~~economised~~ regulated, is a begging the enunciation of a doubt as to the pecuniary value of the Canal when ~~placed in opposition to~~ the cost of rendering the River navigable. It is granted however, that the Canals of Irrigation in these Provinces are returning to the Government Treasury the most liberal profits; a portion of these profits, therefore, all expended ~~in placing the large disposable volume which undoubtedly exists in both the Jumna and Ganges combined with the abstraction of supply for the Canals, in a proper position, it becomes a question to inquire whether the advantages resulting to Navigation and Commerce in the recent step may not counterbalance the injury caused by the abstraction of the water for Canal purposes.~~ in works for the proper regulation of the large supply unquestionably at command in both the Jumna and Ganges even after the utmost demands of the Canals have been adequately supplied; the advantages resulting from the improvement of the Rivers thus effected may fairly be expected to be almost if not entirely sufficient to compensate the commercial community for any injury the abstraction of the Canal waters may temporarily entail upon it.*

From the hills to Delhi on the Jumna, and from the hills to Sookertal on the Ganges, the navigation is restricted entirely to rafts of timber, and to the passage of boats, which are built in the valley of Deyra and with some difficulty and great danger, floated empty down the rapids; from

Delhi

* Note. On the Influence of the Jumna Canals on the Jumna River, see Appendix

Delhi to Allahabad the Jumna with all its windings as affected by the Canal works, is the only medium of water carriage. The Jumna & Canals themselves afford to the timber trade in the valley of Deyra, an immense outlet for wood of all descriptions to the Hurriana and countries to the Westward, as well as to the inland Countries or Districts which are situated above Delhi: at that point, however, the advantages of canal navigation cease; nor are the Canals themselves as navigable lines connected at their Southern extremities with the Jumna so that all craft which leaves the [illegible] or places below Delhi must take directly to the course of that river, and as I have before said encounter such difficulties as the obstruction of water subjects them to, in their downward progress. In such a state of things the

advantages in the Ganges canal would be of immense importance, it would afford navigable lines from the mountains to Cawnpoor, on the Ganges and to a point opposite Calpee on the Jumna; these lines instead of being dangerous and interrupted as the beds of the Ganges and Jumna naturally are, would be comparatively safe and convenient. During the dry months to which I have before alluded the line of traffic on the Canal would be open and unimpeded, and during the rains, when the water carriage of the country is in the greatest requisition, and when the main Rivers

Rivers themselves, ~~removed from~~ relieved from all ~~the injurious~~ the effects of canal abstraction, and giving to the Country the benefits of unimpaired navigation, the Ganges canal would in its central course between the two Rivers provide additional facilities for the conveyance of merchandise, and give fresh means for the distribution of the produce of the Country.

So far on the Question of the injury to Navigation; let us now turn to the Counterbalancing benefits derivable from the Canal. I have in the former paragraphs shown that as a navigable line both in itself and as regards its effects on the parent River, the Ganges Canal has great and favorable claims for consideration. One ~~[illegible]~~ very important fact, however, must not be overlooked, that the original idea ~~[illegible]~~ of a Canal from the Ganges ~~[illegible]~~, was for the purposes of Irrigation, and that although mistaken views at one period of its progress led to ~~[illegible]~~ its being diverted from its ~~[illegible]~~ primary object, it has been from the first both in the mind of the Projector, and in the contemplation of every one who has carefully turned ~~their~~ his attention to the subject, distinctly a line for Irrigation; its uses as a navigable Channel being incidental, and entirely of a subordinate character. To return, however, to the Counterbalancing benefits which might be expected from giving the Ganges Canal

I cannot do better than introduce nearly verbatim the expressions made use of at the time by one who is well able to appreciate the true merits of the question. – "To deny," says the writer, "the value of Irrigation to agriculture in India is like denying the value of manure to an English farmer. The difference between irrigated and unirrigated lands is the first rudiment of his profession which a Revenue Officer has to acquire. It is an axiom in most parts of Hindostan that whatever affords new Irrigation, or cheapens that which exists, gives food and wealth to the people and adds to the resources of the State. Hence the efforts to multiply wells, to form Tanks and to make Canals all over the country. – In Rohilkund, on the Jumna, on all the Rivers between the Jumna and the Sutlej the prosperity of the Country depends on Canals. – In Southern Madras, the waters of the Coleroon and the Cauvery are used for the same purpose, and works are either contemplated, or are in progress, for turning the waters of the Kistna and the Godavery to the same account. – In times of drought, Canals support the Cultivators because they bring the water from a source beyond the reach of the periodical rains, and because they give employment and support to a people who would otherwise be helpless. – Famines may arise not only from a want of food, but from inability to obtain it. – During the Famine of 1837/38 there was good reason

to

to suppose that grain sufficient for one or two years consumption was then in store; in the private granaries in Hindostan there was grain in abundance, and when the Government found the people employment they were able to support themselves on a pittance below the ordinary rate of wages. The cry was not for food, but for money to buy food. The whole population who lived by tillage were unable to till, and were therefore starving. If they could have watered their fields from canals they would have continued to till, and instead of starving would have grown rice. This was illustrated in the case of the Sone Canals at the period of the famine above alluded to, the canal villages were wealthy, on account of the [illegible] of their construction. In Ireland, Railways and an open Coast did little to alleviate the famine that raged in that Country; whilst the people were starving, food was exported from the want of purchasers. It was necessary by employing the poor on public works to give them the means of purchasing food. What public works effected in a wasteful and extravagant manner, the canal is calculated to do in the most beneficial way possible.

Famines do sweep over India occasionally in a most terrible form, and it is not perhaps much which the utmost human skill or foresight can do to alleviate them. No canal can be a substitute for the rain from heaven,

but

out where its influence extends it may incalculably lessen the evil. It may give life to thousands, it may save the thousands from utter destitution, and it may save the Government from that financial injury, which cannot but weaken its power, and impair its energy. But in all seasons irrigation from the Canal will more or less give comfort to the cultivator, wealth to the proprietor, and revenue to the State. Are all these certain advantages to be forfeited because in a part of the year boats will reach the villages on the banks of the Ganges with some greater difficulty than at present?" *

* Note. Remarks by Mr. Thomason Lt Govr. N.W. Provinces.

We now come to the question of malaria, as connected with existing Canals, and its effects on the population of these provinces ~~[illegible]~~; together with the increased evils ~~[illegible]~~ which the opening of the Ganges Canal has been supposed likely to engender ~~[illegible]~~ ~~[illegible]~~. —

In discussing the effects which may be produced upon climate by the introduction of Canals for Irrigation I have in one of my reports made use of the following expressions. "In referring to the low tracts of the Doab and especially to those situated in the Mozuffurnuggur district, my attention has been drawn, during the last two years especially to an opinion, ~~that~~ which has been prevalent that wherever lines of Canal exist in these provinces, the genius of malaria and sickness holds undisputed authority; without producing proofs that are numerous

that

that the epidemics which have ~~[illegible]~~ shewn themselves in towns and villages near the Canals, have been equally felt at others removed from the influence of the canals or of irrigation, it is natural to infer that the introduction of moisture and excess of vegetation on the surface of countries which had been comparatively dry before, must necessarily lead to a change of climate; that change must necessarily demand an alteration in the habits of the people subjected to its influence, and there can be nothing extraordinary when we look to the ways of living adopted by the native community, their lightness of clothing, their indifference to exposure to the night air, their sleeping on the ground, and frequently carrying on their field labors during the night time, as well as during the day, in arriving at the conclusion that the change of a dry for a moist climate some modification of this system is necessary." The paragraph which I have quoted is in my opinion the key to a great deal of canal sickness that takes place, the hygrometrical difference as shewn by the dry and wet bulb Thermometers in regions uninfluenced by Irrigation are extraordinarily great, and the Englishman fresh from Europe, or he who has spent the greater part of his life in the Bengal Provinces, is surprised on reaching the latitudes above Allahabad to find the green to which his eye has been accustomed no longer existing; to find non-

-less

self in plains as round the [illegible] [illegible] [illegible] [illegible] and with the inception of tracts as vegetably totally denuded of verdure; the contrast is a remarkable one and the fact does not appear to have been at all understood by those who without having visited the North Western provinces have been called upon to give an opinion on this subject. Very serious sickness had occurred at Kurnal and Hansi two large Towns with military cantonments attached, which were situated on the Canals west of the Jumna, and to these two cases references were made on all occasions as examples of the evil effects of Canals in general. Without data of a more extensive nature than we had at the time it would have been difficult to say how far the sickness that existed at the above two places as well as at other portions of the North Western Provinces was dependent on the Canals; At any rate before these most necessary and useful works were condemned, it was desirable to have it proved whether the sickness complained of was confined to their vicinity, whether this sickness arose from malaria due to the Canal, or to an epidemic common to the Country; it was also advisable to discover, should it be proved that the sickness does originate in the Canals whether such sickness arises from lands irrigated or from marshes caused by imperfections in the Canal, or from sheets being [illegible], and allowed to remain as stagnant water. Water carelessly used, and allowed to run to waste appeared to be another

another element to the inquiry which ought not to be overlooked, whether it is chiefly in the neighbourhood of rice or in cultivation in general that sickness is prevalent, and whether by carefully embanking the canals, and removing the evils above mentioned, the health of a country might not be restored. The removal of the Cantonments from Kurnal which was situated on the banks of the Delhi Canal, was no doubt a political measure based on the necessity of establishing a more advanced military post towards the Sikh Frontier, this removal however which was popularly attributed to the effects of the Canal, with very severe sickness at Hansi a town situated on the Hansi Branch of it, had been the chief causes of the Canals in the North western Provinces having obtained a character of unhealthiness. The Town and Cantonment of Kurnal were situated on the edge of the high land which skirts the Khadir or valley of the Jumna River, The Delhi Canal which at this part of its course winds through the Khadir on the ancient line given to it by its Indian Projectors, that the foot of the high land on which the Town of Kurnal is built, and to some distance North and South consists of extensive reed marshes which in the decomposition of vegetable matter, and in the harbour that they provide for animals and nuisances of all descriptions most indubitably acted very prejudicially on the health of the neighbouring country. At Hansi the Canal from its want of slope and

and, with its consequently sluggish stream was a nursery for weeds of all ~~descriptions~~ kinds; the ~~country~~ District of Hurriana moreover, of which Hansi is the Capital was previously to the opening of the Canal, in a great measure ~~entirely confined to~~ pasture land; the introduction of water had entirely changed the appearance of the ~~country~~ surface throughout the whole region in which irrigation extended and a richly cultivated had succeeded to a pastoral country. In both these cases the reasons for the occurrence of sickness appeared to be sufficiently obvious. They depended on the abuse rather than on the use of Canals.

The Canal in its Northern parts, and in the neighborhood of Kurnal, notoriously required to be remodelled, but money judiciously spent on silt clearances and in embankments would in all probability have removed the evil even with all the faults of alignment found [illegible] to exist ~~on the faulty line on which it runs, have removed the evil,~~ by eradicating the marshes, and restricting the water to its own Channel. Funds, however, were not available for purposes of this sort at the period to which I allude, ~~the Government was a warlike Government~~. The sickness of Hansi arose in all probability from the ~~causes of~~ effects of change of climate to which I have before adverted, added to the want of expenditure in maintaining the Canal Channel clear and free ~~by expenditure~~ from silt & weeds.

The Eastern Jumna Canal of which is embanked, is not liable to ~~this~~ such marshes as are above referred to ~~explained~~

has

has by no means escaped from the sickness complained of elsewhere; this sickness having been prevalent at Rampoor, Thamlie, Saharunpoor, and in other large Towns in the Southern Districts, whereas the tracts situated to the north, which from their proximity to the Sewaliks and from their jungly character, have the name of being the most unhealthy, have been comparatively ~~escaped~~ free from sickness

Previously to 1843, inquiries had been ~~[illegible]~~ instituted by the Government of the North Western Provinces, as to the progress, causes and localities of the universally reported sickness arising from the Canals; it was the fashion at that period to make the Canals the sources of all sickness, and to hold out the removal of the annual Canton [illegible] as the great ~~[illegible]~~ proof thing of; the reports which were called for at this period from the medical officers of the different Districts ~~[illegible]~~, rather tended to mystify than to clear up the question; Towns stated to be ~~[illegible]~~ suffering under the effects of canal irrigation, were shown to be at a distance and altogether ~~detached from~~ unconnected with the Canals, and sickness appeared to exist quite independently of Irrigation. A report from the civil authorities of the Meerut District ~~[illegible]~~ in calling for Medical aid for the population on the Canal Banks, exemplified in a remarkable degree the feeling ~~that existed~~ which led people to conclude at that time, that sickness and fever must necessarily depend on Canal irrigation. The only Canal

that

that was connected in any way with the Meerut District was the Eastern Jumna Canal, which irrigated a comparatively small portion of it lying to the extreme west ~~of the District~~ and bounded by the Kirsunnee River and the Jumna. At the period to which I allude there was considerable sickness in the canal neighbourhood, but the same sickness ~~[illegible]~~ prevailed throughout the whole of the Meerut District. At the town of Begumabad and the neighbourhood, situated 23 miles East of the canal and separated from it by the valley of the Hindun River, there was sickness equal to anything visited in the vicinity of the Canal, & round Meerut and other large towns with which I at that time was acquainted, and which had no connection whatever with canal irrigation, were suffering precisely in the same way: there was an epidemic in fact ~~[illegible]~~ throughout the Country, with which I imagine the canals were in no way connected, and yet the Canal neighbourhood only was selected as a matter of special reference for medical aid! ~~[illegible]~~ the conclusion arrived at was, that the authorities had taken for granted ~~that~~ what had by no means been proved, and further that the reputation for unhealthiness which the canals in the North West Provinces had obtained (being unsupported by ~~[illegible]~~ the facts ~~that~~ which this enquiry had developed) rested on no sound basis whatever. The question now once forcibly attracted the attention of those who seeing the benefits conferred ~~upon the North West Provinces~~

Of ~~[illegible]~~ of Canal Irrigation, [illegible]
~~were capable of appreciating~~
~~the prosperity that visited through~~
~~and all the villages which came~~
~~within its influence, and~~ were
they are anxious to check any mis-
taken views which threatened to delay
~~[illegible]~~ its extension. "Allowing that
"Canal Irrigation leads to sickness
"in its neighbourhood" they argued
"as this sickness is confined to a
"comparatively small portion
"of the population (a population
"that largely appreciates the ad-
"vantages of Canal Irrigation,
"and as with one voice ~~unanimously~~ calls for it) is it
"considered of sufficient moment
"to prevent the execution of a work
"which can avert the starva-
"tion of the many? Is a sickness
"of this sort to be put in compe-
"tition with the famine of Guntoor
"in 1833, so graphically described
"by Captain Best of the Madras
"Engineers, in which the loss of life
"was fearful, and that of cattle
"so enormous that Captain Best
"clearly shows, ~~that~~ it would have
"been cheaper, viewing it in a
"financial point of view, for
"Government to have expended
"2,21 Lakhs of Rupees (£2,210,000
"sterling) to have prevented it?
"Or the Famine of 1837-38 which led to the sacrifice of a million lives
of [illegible] "raged in ~~[illegible]~~ those ~~districts~~
"~~of~~ the North West Provinces, ~~[illegible]~~
"through the heart ~~[illegible]~~ of which the
"Ganges Canal will run, and
"on account of which the project
"~~of the Ganges Canal~~ was chiefly
"originally ~~[illegible]~~ [illegible], ~~which led to~~
"~~a sacrifice [illegible] Government of~~
"~~a [illegible]~~, already forgotten?
~~[illegible] was sufficient consideration [illegible]~~
~~[illegible]~~

Those who were connected with the project ^felt sufficient confidence in such considerations to satisfy them that the progress of a work so intimately connected with the happiness and security of our North West Provinces would ultimately meet with the liberal attention and fostering care of the Supreme Government.

Whatever might have been the value of the arguments and opinions above given, they resolved themselves after all into mere speculations, and as such were not likely to carry much weight. The researches ~~[illegible]~~ however of the Committee to which I have before referred, ~~[illegible]~~ which was expressly assembled "for "the purpose of reporting on "the causes of the unhealthiness "which has existed at Kurnal "and other portions of the Country "along the line of the Delhi Canal

~~and~~ f. the ~~the Committee will also report~~ "whether an injurious effect on the "health of the people of the Doab "is or is not likely to be produced "by the contemplated Ganges Canal" placed the matter [illegible] ~~[illegible]~~ ~~[illegible]~~. The results of the Committee's labors were arrived at after the most patient ~~investigation~~ [illegible] in the population ~~[illegible]~~ in villages the lands of which were irrigated by the canals; the Members were of high professional and Scientific acquirements, and they were called upon to reply to certain Categorical questions the ~~replies~~ answers to which must have been in one way or the other conclusive. As the Report of this Committee is one of great importance not only to the Ganges Canal works, but to the ~~[illegible]~~ ~~[illegible]~~

future ~~inception of the~~ extension of Artificial Irrigation in the North West Provinces, I have in Appendix B given ~~the paper~~ in extenso, and I will content myself here by noting the principal conclusions at which the Committee arrived:–

1st That an extensive Epidemic had of late years invaded a large portion of the North West Provinces, and especially during and after the rainy season of 1843. That to this Epidemic the sickness which occurred in the Canal districts was partly attributable, and in these Districts the disease was generally, though not universally more prevalent and severe than in other situations.

2nd Fever in a greater degree than usual visited nearly every place in the North West Provinces, and in certain situations neither irrigated, nor the canal near within reach of its influence, fevers prevailed to an extent and with an intensity as great as in the worst Canal villages.

3rd Evils not necessary to Canal Irrigation, but to Irrigation impeded by bad drainage. Natural drainage of the Country checked or interfered with, stiff and retentive soils, and natural disadvantages of site enhanced by excess of moisture. –

4th Considers that if Irrigation was stopped within a Circle of five Miles round Military Stations, their salubrity would not be affected, and that the Effects of Canal Irrigation are remarkably Local. –

5th

5th It recommends certain conservation arrangements in infected near villages, but questions whether advice with regard to mode of life, exposure &c would be adopted and voluntarily practised by the agricultural population."

6th "That the Eastern Jumna Canal furnishes some of the best and worst results of canal irrigation.

<u>Worst</u> where the drainage has been obstructed, and where the soil is clayey as in the [illegible] Division.

<u>Best</u> where the drainage is perfect and the soil is [illegible], as in the [illegible] Divisions.

The result of the Committee's enquiries led, therefore, to the conclusion that salubrity depended in a great measure on the nature of the soil and the efficiency of the surface drainage; it depended in fact on the Irrigation from a Canal being properly regulated, and on the Canal itself being properly laid out, so as not to interrupt the drainage of the country. With reference to the Ganges Canal works "we consider ourselves warranted" say the Committee "in anticipating a far less amount of contingent "evil than has been experienced on "those of the Jumna, which were "originally constructed without "reference to many important points, "which have been kept in view in "projecting the present work, and "more especially in drawing inferences from results on the Delhi "Canal great allowances should

be—

"be made for the natural dis-
"advantages of the Country through
"which it flows when compared
"with the Doab generally."–

With regard to its effects on the surrounding Country, the Ganges Canal had independently of the experience gained from the Jumna Canals ~~[illegible]~~, natural advantages of a very high order for securing the most perfect drainage; its course was on the watershed of the area lying between the ~~drainage within~~ Ganges and the Jumna Rivers; the beds of Rivers or the hollows of ravines were on its whole course ready to receive any cut that might be made for the relief of land lying in the vicinity ~~proximity~~; the whole of the works had been designed with reference to the most perfect system that could be devised for effecting Irrigation with as little [illegible] as possible to the natural drainage of the Country, and by a judicious arrangement of outlets and escapes to maintain an equilibrium of water during the Monsoons and during those periods in the cold weather when the Country was liable to inundation by gradual although heavy falls of rain. The Jumna Canals, on the contrary, were in some respects most inconveniently laid out with reference to the drainage of the Country, the Hansi and a large portion of the [illegible] Canal especially; they had in their original construction been planned without any reference to those points upon which the Committee place such especial weight.– The System of Irrigation

although

although by no means deprived of the benefits of Rajbuhas was, to say the least of it, very imperfect and ~~[illegible]~~ was occasionally of the worst possible description. It did not therefore follow that the evils of the Jumna Canals' irrigation were to be perpetuated on a new line, where every attempt had been made to avoid them. –

The recommendations of the Committee with regard to the measures connected with the execution and management of the Ganges Canal works were judicious; they were summed up in the following terms, and were strongly urged upon the attention of the Government.

1st That the Ganges Canal be kept as much as possible within soil i.e. that its ordinary surface level should be below that of the Country. –

2nd That earth wanted to complete Embankments be never obtained from excavations made outside of the Canal, except in such localities as will admit readily of drainage.

3rd That the Canal and its branches be laid as much as possible along the watershed of the Country, so as not to interfere with the drainage, and in all cases when such interference may be unavoidable, that the Executive Officer be instructed to provide [illegible] for the drainage. –

4th That masonry drains be constructed

-structed under Rajbuhas or Bridges, Ramps, &c, wherever these cross the drainage of the Country

5th That no private water Courses be allowed, but that Irrigation be practised exclusively from Rajbuhas or main water Courses

6th That Irrigation be prohibited within 2 miles of a military station, and within one or two miles of large Native Towns

7th That in clearing embankments the Grass, weeds, &c, be not suffered to rot on the ground, but that they be burned as soon as possible after they are cut.

8th That irrigation be altogether prohibited in localities which appear naturally to possess a malarious character.

In concluding their report the Committee observe that they are aware that their adoption will involve an expense not contemplated in the original Estimate of the Works—

The two main Questions therefore, upon which the further prosecution of the Ganges Canal works depended had been seriously discussed, and deliberately investigated. With the proper application of remedies as recommended by the Committee, the apprehensions regarding the effects of Malaria on the health of the people, were not deemed by the Government of sufficient consideration to warrant the relinquishment of the Project— Nor although the difficulty of obtaining satisfactory evidence on the Question of navigation was

quite

fully admitted, were the apprehensions entertained on that subject considered to be sufficient to justify any departure from the original scheme.

The Supreme Government therefore in a despatch dated 1st May 1847, issued directions to the local Government to prosecute the work with the utmost diligence, on the principle that "the more vigorously the work can now be prosecuted, the cheaper it will be to the State."

From this period, therefore, the Government were fairly embarked in the undertaking; Major Baker was called upon to report on the best measures for carrying out the wishes of Government, and his attention was drawn to the following points regarding the construction of the work which Government had finally determined on.

1st The primary object of the Canal is to be Irrigation, navigation is to be a secondary object, but is to be accomplished so far as may not be inconsistent with Irrigation.

2nd The work is to be constructed in the most complete and substantial manner practicable. This includes the construction of all the works between Roorkee and the Ganges in the manner recommended in Major Cautley's last printed report of 1845 with any subsequent improvements and precautions suggested by Major Baker. The precise course of the Canal and its several branches below Roorkee is yet open for determination.

3rd The precautions recommended by

by the Committee in their report of the 3rd March 1852 (of which I have before given a copy) are to be adopted as far as may be practicable. The first four of these suggestions must be borne in mind in the construction of the Canal. The last four will come into operation after the Canal has been opened and Irrigation commenced.

4th The available water power is to be employed as extensively as may be practicable for moving machinery at suitable places for the erection of such machinery, where there may be no immediate demand for it provision should be made for its future erection.

5th In taking land for the Canal, arrangements are to be made for the formation of Reservoirs and plantations on the plan which has been adopted on the Jumna Canals

As the above rules are those upon which the work has been conducted, I have considered an introduction of them verbatim as an interesting feature of my narrative. There was some discussion at this time on the subject of the more southern districts, and as to those which would derive the greatest benefit from the Canal; as these were questions, however, which depended on close surveys of ~~[illegible]~~ contour, they will be more fully entered upon hereafter; it was evident however that the surveys for my original project ~~which was based on surveys~~ ~~for the~~

having been made for
the purpose of discovering the watershed or backbone of the Doab, and therefore conducted through one line of Country merely; were insufficient for laying down branch lines, or of determining through what districts such lines might be most advantageously carried. -

Major Baker's report was addressed to the Military Board, and dated the 13th of April 1847, the document is an exceedingly interesting one, and as it bears upon the whole of the question, and defines the rules upon which the Executive Officers and others have been since guided in the progress of the work, an abstract of its contents will in this place be explanation of the views that were then entertained on the subject.

Major Baker's plan of operations was founded on the following considerations: -

1st That a very small portion of the Canal can be brought into use, before the Solani Aqueduct is completed. -

2nd That Earthwork in Channels and embankments being liable to much injury from the weather, and consequently requiring extensive repairs, it is desirable that these should not be completed before the Masonry works

3rd That the whole project including both main and branch lines should be completed at once both with a

a view of bringing the whole into operation as soon as possible and to admit of a full supply of water being used, which would not be the case unless the branches were ready to receive their respective shares

The rapid completion of the Solani Aqueduct was a necessary desideratum under the above considerations; and it was proposed to concentrate all means upon this work, by which the object would ~~be~~ in all probability be gained in six years The Calculations on which this was based were as follows:-

The Cubic content of the aqueduct being 874,9524 Cubic feet, the following quantity of Materials would be required for its completion

Bricks 12"x6"x2½"	for building	69996192
Do	Do for Soorkee	13474258

Lime in Cubic feet 962447, or in round numbers 10,00,000 Cubic feet of Lime and 850 Lakhs of Bricks.-

The work people required in preparing and using the Materials would be as follows:-

	Laborers
In brick making inclusive of [illegible]	3143333
in building Masonry and laying floors &c	781946
on pounding Soorkee	641632
In [illegible] the Bricks	311044
In the Earthwork of the aqueduct inclusive of draught cattle	1197,2750

Brick making to be completed in 5 Years allowing 190 days in each Year (deducting Sundays and rainy season, would require for them 1149 Brick moulders and 3309 Laborers.-

The

The remaining work to be completed in six years, allowing 250 working days per annum, would require 264 Bricklayers and 2471 Labourers per diem. The workshops would require 50 Smiths, and 50 to 100 Carpenters per day, and an establishment of about 1000 Bullocks, exclusive of Contract carriage would be required for the earth wagons and other purposes.

To those who are unacquainted with the part of India in which the above works are situated, and with the system which the nature of the people and of the country itself, renders necessary in the Department of Public works, it may ~~~~ be advisable to point out here that there are no contractors to be depended upon for the supply of material. The Engineer as the Architect has to make his own Bricks, and to burn his own Lime, he has to purchase his supplies of Timber, and in many cases to proceed to the Forests himself to superintend its collection. He has in fact neither Contractors for making his material, nor Contractors for putting that material together; he is literally driven to his own resources, and although the Contract System in a limited sense, is by no means misunderstood in these provinces, it is confined to the Manufacture of material in small quantities, and to the Excavation of Earth, the latter being a trade which has long thrived both in the Punjab and in the more Southern States. The trade of the Earth Contractor

contractor must have originated in the great demand for Tank or Reservoir digging which exists both amongst the Mussulman and Hindoo population, [illegible] ~~to the demand~~ for water courses or the Canals for Irrigation. There are tribes of a wandering class, whose chief if not entire occupation is ~~limited to Earth excavation~~ digging Tanks and water courses and to these people we are indebted for the greater part of all our canal excavations. The respectable and wealthy class of Contractors which in Europe relieves the Engineer and the Architect from the detail of building, is unknown in the North Western Provinces of India; the difficulties therefore that ~~lay in the way of~~ [illegible] the ~~Inspector~~ Director of the Ganges Canal works at the early period of their establishment may be fully estimated. –

In continuing his Report Major Baker when referring to the Executive Establishment that would be ~~required~~ necessary, drew especial attention to the unusual quantity of material that was required for the construction of the Solani Aqueduct, the position in which it was placed with reference to supplies; and the impracticability of ~~supplying~~ [illegible] our wants excepting by the exertions of our own Establishments; the appointment of an Officer expressly for the purpose of superintending the manufacture of material for the Solani Aqueduct was recommended. This Officer's duties ~~were~~ were to be ~~confined entirely~~ restricted to the Northern

Division

Division, to which a second Executive Officer was to be appointed for the supervision of the works. Five other Executives were recommended for the works south of Roorkee, their Divisional duties being confined within certain limits detailed in Major Baker's report.

It was proposed that the whole of these Officers should as early as possible after the close of the rains of 1847, or in the month of November of that year, employ themselves in obtaining an accurate survey of their respective Districts, and such a series of connected cross levels, as would enable them in consultation with the Director of the works, to fix on the best possible line for the Canal. They would burn bricks wherever fuel ~~[illegible]~~ might be available along the probable course of the Canal and in quantities proportionate to the probable requirements. On the approval of the line by the Director, it would be carefully marked out, and masonry bench marks established and to use the words of Major Baker's report "The "principal masonry works "would then be commenced, and "a careful calculation having "been made of the quantity "of excavation in the channel "and the time required for its "execution, the ground would "be taken up and the excava-"tion be commenced with such "reference to the progress of the

Solani

"Solani Aqueduct as would admit "of the simultaneous completion "of all the works".

The extent of the Divisions which were thus told off to the different Officers was arranged on the supposition that the 3rd project which I had in my Report of 1845, recommended for adoption, would prove to be the most desirable, but before this could be determined on, accurate Surveys of the Country were required: it was therefore proposed that the Director should personally visit the different Districts and in communication with the Civil authorities determine the best and most favorable lines upon which Irrigation could be extended with the greatest benefits, this determination would necessarily be based on the results of the different Surveys and levels upon which the Executives were to be engaged during the cold season of 1847-48 regulated by the instructions conveyed in the report of the Medical Committee. In the meantime the progress of the works in the Northern Division, or in that portion between the Hills and Roorkee, especially that of the main works at the Canal Head and on the Solani River, would go on unimpeded, their position having been accurately determined in the earliest stage of the Project.

The Establishments which Major Baker recommended was in accordance with that in my report; it gave to each Executive

the

the receiving and independently of that of two Assistants in his executive duties . .

English Office

	Rs.	
1 English Accountant	100 ..	
1 — Do — Writer	45 ..	
1 — Do — Assistant — do	25	170 ..

Native Office

1 Moonshee	30 ..	
1 Assistant — Do	15 ..	
1 Native Surveyor	25 ..	
1 Native Do Clerk	15 ..	
2 Sowars — @ 15 Rs each	30 ..	
1 Duffadar	6 ..	
4 Burkindauzes @ 4 Rs each	16 ..	
1 Chuprassie	6 ..	
2 — Do — @ 5 Rs each	10 ..	
4 Classies — @ 4 Rs each	16 ..	169 ..

Treasury

1 Treasurer	20 ..	
1 Assistant Do	10 ..	
1 Jemadar	8 ..	
1 Duffadar	6 ..	
16 Burkindauzes @ 4 Rs each	64 ..	108 ..

Works

1 Mistry Smith	25 ..	
1 — do — Carpenter	25 ..	
1 — do — Bricklayer	15 ..	
1 — do — Do	12 ..	
1 Jemadar of Chuprassies	8 ..	
10 Chuprassies @ 5 Rs each	50	135 ..
Per Month Total Company's Rs		582 ..

With permission to employ on detached works under Overseers.

1 Mohurrir @ 10 Rs per month

1 Chuprassi @ 5 Rs do

and a Guard proportionate to the Stores and Treasure in his charge was also recommended

In reviewing the System of Accounts as practised in the Department of Public Works, Major Baker drew the attention of the Government

Government to certain points which appeared to him inapplicable to the expenditure on the large works of the Ganges Canal. Under the system now in force the Engineer in charge of the works keeps detailed accounts of expenditure, and on the completion of a work submits a Bill for audit, in which the actual rates of work are compared with those of the Estimate. If the Estimate be not exceeded, or the excess be satisfactorily explained, the Bill is passed, and the Executive Engineer is relieved of its amount.

Major Baker argued that if this system was observed in the Ganges Canal; the expenditure on the Solani Aqueduct, the Myapoor Regulator, the Dams and principal works of the Northern Division, would not come under revision for many years, when the work would have passed through the hands of several Executive Officers, and when the money being spent, the check would be retrospective and inoperative, and that the amount of money at the personal risk of Executive Officers would accumulate up to the completion of the works to an extent that would be felt as a grievous burden, whilst the arrangement of complicated and long standing accounts would engross the time and energy which would be more profitably expended on the actual arrangements for work –

Major Baker therefore proposed for adoption a system which

which he considered more applicable to the Ganges Canal Works, and as this system was approved of, and as far as possible was carried out afterwards, I shall give it here in Major Baker's own language. -

I. The works shall be executed agreeably to Major Cautley's designs, no deviation from which will be made by the Executive Officer without the sanction of the Director of the works, who will report the same to the Military Board.

II. When money is required for the execution of work, applications will be made by the Executive Engineer through the Director to the Accountant North Western Provinces, who will issue an Assignment for the Amount.

III. The Executive Engineers will send Monthly to the Director, detailed Accounts of their Expenditure, viz^t; -

1. List of Establishment
2. Account of work people employed and materials expended in each work, and measurements of work done
3. Quantity of Contract work and its cost. -
4. Amount of advances for Contract work -
5. Amount of advances for Materials
6. Quantities of Materials received
7. Do do Do expended

IV. The Executive Engineers Monthly Accounts will be abstracted in the Director's Office, and after examination

-xamination will be forwarded for Audit to the Military Board accompanied by a Special report having reference to the following tests. –

1. The Regular Establishment charged will be compared with that authorized by Government.
2. The Subordinate Establishment for the Supervision of work will be tested by the extent of work in progress. –
3. The work expenditure will be tested by the extent of work done.
4. The Number of workpeople by the known Amount of the mans labor, their rates of pay by the ordinary rates of the District.
5. The Quantity of material used by what is known to be necessary for each description of work. –

V. On completion of any work the Director will draw out and submit to the Military Board a comparison of its actual cost with that Estimated.

VI General accounts of Expenditure on the Canal works of all descriptions will be kept in the Directors Office, and Balance Sheets will be submitted to Government Quarterly or half yearly as may be required

VII. To carry on the plan as above detailed, an Accountant with the requisite number of Assistants would be required in addition to the present Establishment of the Directors Office

Major Baker in soliciting

the

the favorable consideration of the military Board to the above system of Accounts, observes that although it would involve a greatly increased amount of labor to the Director of the works, it would place in his hands a control over the expenditure, and an insight into its details which under the existing system would be difficult of attainment, if not impossible, and that the labor and responsibility saved to the Executive Officers would be proportionately much greater than that entailed by the new system on the Director. –

Major Baker concludes this very interesting report, by pointing out, that to place the Establishments of Executives and assistants on the footing which he has proposed, 7 Executives and 14 Assistants would be required. Of this number there were at the time 4 Executives and 4 Assistants available, leaving a deficit of 3 of the former and 10 of the latter; in the latter capacity Major Baker recommended the employment of 3 or 4 sub Assistant Civil Engineers, or young Students from the Roorkee College, should so many be available. It was urged by Major Baker that nominations to these appointments should, as the period at which he was writing was unfavorable to field work, be deferred until the Month of September, so as to admit of the work being set in active progress after the cessation of the rainy season

-sion.

Major Baker accompanied this report by a statement of the Expenditure which had been incurred on the Ganges Canal works up to the 30th April 1846, of which the following is an abstract

Northern Division						
Excavation	354526	5	6			
Masonry	19783	2	9			
Materials and Sundries including Establishment	219032	6	7	593340	14	10
2nd Division						
Excavation	93903	9	4			
Masonry	1267	4	..			
Materials and Sundries including Establishment	80095	10	6	175467	7	10
Director's Office Establishment &c				33894	6	5
Grand Total Expenditure up to the 30th April 1846. Co's Rs				802702	13	1

The suggestions and recommendations which had been made in the above Report, were entirely approved of by the Government in its letter of the 25th August 1847. ~~entirely approved of by the Government~~. A Quarterly system of Accounts, similar in every other respect to that proposed by Major Baker, was however considered to be better than the monthly one; and Rules to the following effect were laid down for future guidance.

"In the Northern Division, the Executive Engineer of works will submit Quarterly to the Director a Bill for 3 Months work prepared in the usual departmental form i.e. exhibiting Quantities, Rates, and Amounts, and accompanied by detailed measurements of work done.

"The materials used to be charged

for

or on the rates furnished by the Executive Officer of Materials

"When the rates of work differ from the Estimated rates, full explanation to be given at the foot of the Bills in the usual manner.—

"The Bills after careful examination by the Director will be submitted with his remarks to the Military Board.—

"The Executive Officer whose duty it will be to collect and prepare Materials, and to take charge of Bullocks, Carts, &c, will submit quarterly to the Director for transmission to the Military Board, a detailed statement of expenditure and results on each item of his charge including Carts and Bullocks, accompanied by such explanations as may appear to be necessary.—

"To the above Statement will be appended a Balance Sheet shewing on one side the actual expenditure on each item, and on the other the amounts received from the Executive Engineer of works and the Stock in hand.—

"He will also submit a list, deduced from the above mentioned accounts, of prices of Materials, Bullock hire &c, which he proposes to charge during the ensuing Quarter, to the Executive Engineer to whom it will be communicated by the Director if approved.—

"The Executive Officer of Materials will get advances from the Executive Engineer of Works, and will write off per Contra, the value

of

of Materials supplied.—

"In the smaller Divisions it may be expedient, from motives of economy, to unite in One Office the functions of the two allowed for the 1st Division.—

"The Executive Engineer of a smaller Division will, therefore, keep and submit Quarterly to the Director distinct accounts of Works and Materials as laid down for the 2 Offices of the 1st Division.—

"On completion of any work extending through more than One Quarter, the Director will draw out and submit to the Military Board, a Comparison of its actual Cost with that Estimated, at the same time report[ing] on the Quality of work, &a. Every work commenced and completed during the Quarter will, by the [illegible] be separately reported on, as to its quality, &a.—

"General Accounts of Expenditure on the several works of all descriptions will be kept in the Directors Office, and Balance Sheets will be submitted to Government, Quarterly or Half yearly as may be required."

In providing Major Baker with the above rules it was [n]oted that if he "considered it necessary to increase the strength of his own Office Establishment in order to conduct this new system of accounts with punctuality and efficiency, he was authorized to entertain an Accountant on a Salary not exceeding 300 Rupees per month, and 2 Assistants on a salary not exceeding 100 Rupees each per month."—

The

The forms of Accounts and papers which were submitted on the above system will be found in the volume of Tables, ~~and I now submit as the most appropriate place, add in certain remarks on the system in general, and the working results during its progress under my management~~

On the 1st of October 1847, a series of Instructions were circulated to Executive Officers on their proceeding to commence field work, to examine the Country as before explained, and to determine the best line upon which the Canal and its branches should be carried. A copy of these Instructions will be found in the volume of Tables. In the meantime ~~the progress of~~ the different works in the Northern and in the early part of the 2nd Division in the Mozuffurnuggur District were proceeding with all the vigor that additional means had instilled into the Establishment, and at the period when I rejoined ~~the works~~ early in 1848, I found everything prepared both in money and Establishment for carrying on the works with the utmost energy.

Chapter III
Final period under the Direction of Lt Col. P.T. Cautley
From 1848 to 1854

Major Baker delivered over charge of the works to me on the 11 January 1848, with the necessary Memoranda as to progress

progress and expenditure, and it may be interesting here to place upon record the state of the works at this period, as well as the amount of money that had been expended upon them.

I have in the volume of Tables and Appendices (Appendix E) given in full the Report on the state of the Ganges Canal works at or about the period when Major Baker delivered over charge to me. The introduction of this paper in all its fullest details is necessary to show the progress that had been made up to this period, together with Major Baker's views on points connected with the annual project. I may observe however that independently of the Brick foundations, and of the guide Revetments of the Solani Aqueduct which had been commenced, very considerable progress had been made in the works at the Myapoor Dam. The Regulating Bridge at that point, together with the Bridges or cross communication at Kunkhul, Jowalapoor, Moungoon and Bogpoor, were in an advanced state, the Arches and superstructure of the Myapoor Regulator being very nearly completed. The foundations of the Bhula Falls had been commenced upon. Numerous Chuki buildings had been finished, and Excavation was either in progress or had been completed from the 1st to the 10th mile of the course of the Canal.

On the 31st December 1847,

the

the State of the Expenditure was as follows.

Northern Division		
Excavation	[illegible]	
Masonry	[illegible]873	
Materials and Sundries including Establishment	433[illegible]	1107[illegible]
Mungleur Division		
Excavation	302[illegible]	
Masonry	[illegible]3 5 5	
Materials and Sundries including Establishment	[illegible]	15[illegible]
3rd 4th 5th & 6th Divisions		
Preliminary surveys Establishments &c.		[illegible]
Director's Office Establishment &c		[illegible]
Grand Total Expenditure on the 31st December 1847.		170,039 8 5

(continued Page 113)

Note

Major Baker's plans having determined him to leave the Works in December, I quitted England at the end of August 1847, for the purpose of reassuming the duties that I had left 3 years before, and of relieving Major Baker from a charge, which had by the most judicious management on his part, and by the best tact in the organization, become one of comparative ease and simplicity. My object in leaving England at such an early period was to visit the Canals in Lombardy and Piedmont, and make myself acquainted with the method of irrigation, and the Works connected with the regulation of the course of Rivers for which the Italians have been long celebrated: to do this my time was limited to the space of about six weeks, but during that period I inspected the

Head

Heads and Reservoirs on all the Canals in the neighborhood of Milan, examining in detail the ~~bed~~ course of Ticino River ~~from its de-~~ ~~-parture~~ from Sesto Calende to the Mouth and along the line of the Naviglio Grande to the town of Buffalora. ~~as well as~~ I visited also the Locks and other interesting works for navi-gation on the Pavia Canal. In Lombardy ~~[illegible]~~, I saw for the first time the (Fontanili) method of collecting water for Irrigation by tapping springs, and by these means, providing Irrigation for considerable tracts of Country. The Milanese modulo for regulating the discharge from the Canals, and the Meadow (marcite) Ir-rigation with all the attention which that system necessitates in levelling and equalizing the surface, were objects of peculiar interest; I inspected also some very interesting and successful works although on a small scale, for the riddance of Silt from a Canal in the neighborhood of Bergamo; and in the vicinity of Mantua and Cremona, became acquainted with the bunds and works of that description for which the River Po is celebrated.

In Piedmont the Canals from the Dora Baltea, and their Heads in the neighborhood of Ivrea, were inspected in great de-tail, as although the Canals them-selves carried comparatively to those in the North West Provinces of India

India small volumes of water, they were connected with mountain Rivers subjected to violent floods, and therefore liable, ~~although in a less degree~~, to evils similar to those with which we have to contend. The works over the Po connected with the Genoa Railroad, situated near ~~[illegible]~~ Moncalieri, as well as the Bridges either building or built over the numerous tributaries which cross the high road between the Ticino River and Turin were all of them subjects of great interest. At the time that I visited Turin a masonry Bridge over the Stura River was in progress of construction, the River at the point where the Bridge was ~~building~~ being built took a considerable curve at which a wooden Bridge kept up the line of communication; the Engineer had fixed the site of his masonry Bridge on the chord of which this curve was the arc. The Bridge in fact was being built on dry land, and under circumstances, precisely similar to those which we are constantly in the habit of adopting in these provinces: the proposed design of making ~~[illegible]~~ a straight cut to deliver the stream upon the Bridge, and the system of Bunds and Spurs on the upstream side of the works, for the purpose of regulating the River in its new course ~~upon the Bridge~~, were observed by me with much attention. The character of the Stura River at the point in question ~~seems~~ was exactly that

that of the mountain torrents (or Nadi as they call them in the North western Provinces) at the foot of the Sewalik Hills, a wide straggling shingly bed, depressed below the surface of the country to a very moderate degree, fringed and scattered over with long grass, and from its appearance running on a considerable declivity. A set of plans descriptive of the works of these operations, was purchased by me from the Office of the Board of Works at Turin for our Ganges Canal Library, and as I consider these plans to be admirably descriptive of the system of bunds and spurs adopted by the Italian Engineers for regulating and directing the course of rivers, I would recommend them to the Department of instruction for ~~[illegible]~~ the Civil Engineer's College at Roorkee. With the exception of some Canal works in the neighbourhood and to the North of the town of Novara, and to the works for Hydraulic instruction near Turin, I saw nothing further in Piedmont, but I regretted exceedingly that the limited time that I had at my disposal prevented me from making a further stay amongst works from which I had already gained a great deal of valuable information, and from the Engineers of Turin the information which I required was imparted with the utmost spirit and liberality. Should my friend M. Carlo Noe, the Inspector

of

of Canals on the Dora Baltea ever cast his eye on these pages, I trust that he will accept the expressions which I now make as a small return for the time and trouble which he as a perfect stranger, and without my having any intro-duction to him, so kindly devoted to my service. –

Captain Baird Smith who two years after my visit was deputed by the Honourable the Court of Directors of the East India Company to Lombardy and Piedmont, for the purpose of reporting on the works for Irrigation in those provinces, has in his two admirable and instructive volumes entered so fully into the subject, especially into that in which the Fiscal and Legislative Management are concerned, that the few remarks which, before dropping the subject, appear to me to be in this place necessary, must be confined to the impressions that my mind received on visiting works the reputation of which had been for so long a time familiar to me. With regard to the Canals in Lombardy I confess that I was disappointed, this disappointment however did not arise from the works themselves from which I not only derived great instruction, but a number of useful hints from which I have largely benefitted in designing the Ganges Canal works; but from the peculiarity of their position, and if not their entire freedom from the effects of mountain torrents, their connection with them under

such

such peculiar circumstances, that the effect of their contact, which is a source of such difficulty and danger in the Canals in the North West Provinces of India, is almost entirely neutralized.

The Ticino and Adda, from whence the great Milanese Canals to which I have before referred, derive their supply, have their sources in the large Lakes which lie at the foot of the Alps to the North of Milan; the Lago Maggiore in the case of the Ticino, in the case of the Adda, the Lago de Como. The torrents which during the rainy months come down from the Mountains with equal force both in Italy and India, are in the former case received into the bosom of these Lakes, where they exhaust themselves over very extended surfaces before the effects of the influx of water can be felt by the Canals, in the latter, they cross the lines of Canals with violence unmitigated by any intervening circumstance" It is scarcely "possible" as Captain Baird Smith observes when adverting to these large Lakes and the influence that they exert on the Canals in Lombardy, "to overestimate the "value of this natural ~~[illegible]~~ arrangement "it is one for which Lombardy "has constant cause to be grateful to a Skill above that of "man, and looking to the natural features of the Country

it

"it is perhaps not too much
"to say that without it the
"Rivers flowing directly from the
"mountains would as often have
"blighted the land by their des-
"tructive floods, as blessed it
"by the discharge of their fertiliz-
"ing waters"

~~With an almost total relief~~ Being then almost entirely relieved from the Effects of Mountain torrents, ~~and with an entire relief from those evils~~ in crossing their alignment with an admitted superiority of Soil which is highly beneficial to the beds of the Canals, and affords the greatest stability for foundations; and with the finest Material in the world perhaps - viz^t. the Granite from the Baveno Quarries from which to build ~~the~~ his works, the Lombardese Engineer is placed in the opposite extreme to his brother Engineer of India, who without the slightest exaggeration has to deal with the Mountain Torrent in all its deformity, with illimitable depths of Sand, and with difficulties in procuring Material ~~to a degree that~~ such as would hardly be credited without personal knowledge of them

There were very striking features in the working of these Canals, however, that could not escape my notice, and perhaps the most remarkable one, was the use of the simplest means and the simplest expedients in all cases where regulating supply was necessary; the simplicity of the means in raising ~~up~~ their Sluice Gates; for

for relieving and filling their Lock Chambers - for fixing the Gates of their Locks, and for reaching the force of Currents by Piles, were matters of very great interest to me, and the interest was enhanced by observing that this simplicity of means had its desired end, ~~and that the result was~~ in producing real efficiency. -

It may be observed however that the variation in surface of these Canals during the year is not more than 12 or 18 English Inches, that this freedom from floods and over charges of water (arising from the circumstances above described in their connection with the Lakes) gives them a security which no Canal in the North West Provinces of India can hope to enjoy: ~~and it leads to the circumstance which is at once very remarkably illustrative of the immunity that these Canals hold from inundations, that works to regulate the supply into the Canal Heads are not considered necessary.~~ -

The most noteworthy consequence of [illegible]

The Canal Works of Lombardy therefore, were to me wanting in the main point to which my views were directed, the River Works however, were full of interest and I found with regret that the intention that I had started with, of visiting the Po in the neighborhood of Ferrara and the Adriatic was frustrated by the necessity of my having to reach Trieste in time to join the Steamer that was to carry me to Egypt

And

and ultimately to India. —

The canals which I visited in Piedmont were taken off from the Dora Baltea a mountain River which during the cold weather is subject to floods of a very violent description; the canals themselves are, compared to those in the North West Provinces, small, they are not used for navigation, and are regulated at their heads by a series of small sluices worked by hand spikes; the sluices themselves being arranged in a covered Bridge which crosses the canal head, and which entirely precludes all possibility of danger from sudden rises in the surface of the River, and ~~entirely precludes~~ the passage of boats. —

The ~~means by which the~~ water is taken from the River and directed to the mouth of the canal ~~is~~ here as in Lombardy ~~obtained~~ by a Masonry weir unbroken in its whole length excepting at ~~one~~ two points through which the surplus water escapes with great violence; between this weir and the Regulator are sluices ~~entirely~~ detached from the weir, for the purpose of passing off surplus water into the bed of the River and by these means regulating the canal supply. — In Lombardy precisely the same plan is adopted, and in the case of the Muzza canal, the weir extends completely over the bed of the River, and the

the regulating sluices which are situated between the head and the Bridge of communication for the Railroad, are of the same description and on the same principle as those used in Piedmont.. Within the ~~late~~ last few years before I visited the works in 1847, it had been found convenient on the Muzza canal to multiply the number of these escapes.. This system of detached sluices in the position which I have above described is much approved of by the Italian Engineers, as independently of giving a ready escape for surplus water, they provide a scour, and thereby the means of getting rid of the silt and deposits which invariably establish themselves in the mouth of the Canal

On the Lombardy canals and under the advantages with which their water reaches the canal heads, the elevation of the sills of the weirs does not appear to be of serious consequence in raising the beds of ~~them~~ them on the up Stream side; In Piedmont on the contrary where the weirs are built over Rivers directly running from the mountains, the effects of deposits above the weir as might have been expected are of a very serious nature; at the time that I visited Ivrea and the head of the Ivrea canal, this evil ~~of silt deposit~~ appeared to me to have reached a maximum, and large parties of Laborers

Labores were employed in the water in removing the ~~deposit~~ [illegible] and clearing an open channel in the direction of the Canal Head. It has been found expedient in the Canal works in the North West Provinces of India to avoid as much as possible any elevation of silt to the Masonry Dams which cross the Rivers at the heads of Canals; these Dams are in fact a line of Sluices with Gates or Shutters which are capable of being entirely laid open down to the bed of the River during the prevalence of floods, ~~and~~ in rapidly rising Rivers like those in India the method which has been adopted by our Engineers is, I believe, the most appropriate. In some cases perhaps it might be modified with advantage, where the head supply for the Canal must necessarily be raised to a considerable height above the Dam flooring, as in the case of the Myapoor works at the head of the Ganges Canal, ~~but the [illegible] of [illegible] location shows itself more in the value to be derived from the reduction of extent of sluice openings, with the increased facilities for relieving these openings during floods, than from any particular advantage in the maintenance of supply.~~

[illegible], or advantage [illegible] would [illegible] increased facility of management during floods due to the diminished area of sluice surface rather than to any particular benefit in the maintenance of supply.

As far as my travels extended in Piedmont I looked in vain for examples of Canals crossed by mountain Torrents after their departure from the source of supply, with the exception of a case north of Novara where the Agogna River is crossed by a Masonry Channel

carried

carried under it, or by a "Salto di Gatto" (a Catsleap) as the Italian engineers call it, I saw nothing approaching to the great cuts which renders our Canal Engineering in India a matter of such serious difficulty. The Mora Canal which crossed the above mentioned River was a mere water course and would have come under the denomination of a 1st Class Rajbuha in the N.W. Provinces; whilst the bed of the Agogna under which it passed did not exceed 150 feet in width. The River at the point where the Mora crosses it has a well defined deep section, with a shingly bed nearly dry at the period of my visit in October, and is crossed by a Bridge of 3 Arches at a distance of about 100 feet above the line of Canal.

I cannot leave the subject of these Italian Canals and their works, without an expression of surprise mixed with a good deal of satisfaction, at the numerous instances in which we who were entirely separated from all communication with the Italian Engineers had, by the mere process of simple reason, arrived so frequently at precisely the same results, and in so many cases had adopted the same expedients; this is remarkably shewn in the protection given to the Aprons and tails of their weirs. When standing on the weir at Ivrea I could have imagined that I had before me the works of our native Establishment in India; in all

their

their temporary bunds, spurs, and plank protections to Cuttings; the devices for making them useful and efficient, are very much the same in both countries; and the feeling that exists amongst the Italian Engineers of introducing the utmost simplicity into their works, so that the Establishment which consists generally of village people may perfectly comprehend the way; and means to which machinery may be applied, accords peculiarly with the experience that we have gained in our dealings with the same class of people who have the charge and supervision of detached works on our Canals. The system of Retaining Dams, or Bars constructed across the bed of a River for the purpose of holding up the bed to a fixed level, ~~and~~ which appears to be practised universally both in Lombardy and Piedmont, is another example of expedients being devised by simple inductive reasoning, without the parties having any connection or communication with each other. The retaining Dams on the Muskurra and Nogong Rivers, two of the Mountain Torrents which cross the line of the Eastern Jumna Canal, have their representatives on the Po at Turin, on the Serio River at the village of Albino near Bergamo, and on a River from whence a supply for Mills (and on which the Hydraulic Establishment is situated) is taken near Turin, in the latter case the Retaining Dam is placed [illegible] ~~[illegible]~~ a weir

made

made of [illegible] and shingle which is thrown across the bed of the River for the purpose of turning water into the Canal; and the retrogression of levels upon which led to the necessity of its being protected [illegible] ~~Contributes in some appreciable degree~~ ~~this result [illegible]~~ [illegible] in the [illegible] Provinces. In the other places to which I have alluded the retaining Dams are built on the downstream side of Bridges, and with the intention I presume, of protecting those works from the effect of retrogression.

I ~~[illegible]~~ remark on the Piedmont Canals that the immediate connection of their beds with mountain Rivers, renders them in some degree liable to the dangers from inundation and accident to which the Canals in these Provinces are subjected. The circumstance of their being very much smaller however, of their not being available for Navigation, of their heads being protected and crossed by a bar of masonry pierced with small and easily worked sluices for the admission of water, and often not being crossed by lines of Mountain Torrent, place them [illegible] on a scale inferior to the Canals for Irrigation in the North West Provinces of India. –

~~Dams~~ In my progress through Egypt I visited the works at the Head of the Delta of the Nile, which were at that time under construction on the designs of a French Engineer, with the Egyptian cognomen of Mousel Bey

Belt, ~~and which I may describe as passing in the form of a Dam or Bridge~~ are intended to maintain the River at the point where the Rosetta and Damietta branches separate, on levels appropriate to the supply of 3 Canals which are ~~intended~~ to be taken from

On the 14th December 1847, I reached Bombay, and on the 11th January following, resumed charge of the Ganges Canal works from Major Baker, having in the few previous months, travelled over some of the finest fields of Artificial Irrigation in Europe, and having derived as much benefit as I could from the inspection of numerous works devoted to the peculiar object on which my time was hereafter to be occupied. —

(continued from Page 99)

The Staff which was attached to the works ~~at this period~~, and the duties upon which I found them engaged on my return to Office was thus: —

In the Northern Division which extended from the head at Hurdwar to a point 4½ miles below Roorkee, Lieutenant H. Yule (who in the month of ~~March~~ following was succeeded by Lieutenant A. G. Goodwyn) the Executive Engineer in charge of the works had under his orders. —

Lieutenant Price of the 1 Bengal Fusiliers
Mr Wilkan
Mr D. Login } Uncovenanted
Mr J. Parker,

The

the works in progress were general throughout the Division. Sergeant Firm, a Canal Officer of great experience ~~was~~ being in charge of the material Department, of which he had shortly before ~~taken~~ charge. —

In the 2nd Division which extended to the 110th mile running through portions of the Saharunpore Muzuffurnugger and Meerut Districts, Lieutenant Fraser of the Engineers, who was the Officer in Executive charge, had under him as assistants

Lieutt Dempster of the Bengal Artillery & Mr J. Read Uncovenanted. Excavation had been in progress in this Division from the earliest periods of the operations, and before I left India. At the time of my rejoining the works, considerable advancement had been made, and parties were excavating as far south as the 60th Mile; the collection of bricks and other material ~~collecting~~ ~~were~~ in active progress throughout the whole of the Division, and in the more northern parts some of the Masonry works had been commenced ~~finished~~ ~~in~~; the Mungpore and Toomailpoor Bridges having been completed up to the spring of the arches. —

In the 3rd Division, Mr Volk who had been appointed Executive Officer for the Superintendence of the works with Lieutt Merrick of the 3rd N.I., & 2nd Lieutenant Newmarch of the Bengal Engineers, [illegible] were engaged in surveys and levels of the Country and were

collecting

collecting the necessary data for laying down the main line of the canal. This Division extended through portions of the Bolundshuhur and Allyghur Districts as far south as the Town of Koel.

The 4th Division had been placed under charge of Lieutenant Hodgson of the Bengal Engineers; this Officer with Lieut. Dumbleton of the 10th Cavalry, as his assistant, was employed on the Surveys and Levels of the country lying through the Allyghur and Mynpoorie Districts.

The 5th Division which consisted of the line of country in which it was proposed to carry the Etawa Branch, was unoccupied.

The 6th Division was filled by Lieut. Charles Hutchinson of the Engineers, with Lieut. Hume of the 48th Regt. of N.I. These Officers were ~~employed~~ employed on the Surveys of the Country in the Furruckabad and Cawnpoor Districts, in extension of the line occupied by Lieut. Hodgson.

In addition to the above Officers who were strictly attached to Divisions, Mr Dodsworth a Surveyor was engaged in carrying on a series of Longitudinal and Cross Sections on the line of country between the Rinde and the Jumna River for the purpose of determining the best line of direction for the Etawah Branch or that which had been fixed upon as the 5th Division.

It will be understood therefore that at the period to which

I am referring, Excavation and Masonry works were in progress from the Canal head to the 50th Mile of its course; beyond that point, the surveys and levels of the Country upon which the direction of the Canal had to be determined were still in embryo.

The works at this time had been proceeding on the plan laid down in the 3rd project which I had submitted to Government previously to my departure for England in 1845, ~~neither then in any of the others which I had suggested for the consideration of Government, varied either in direction or in works on the first hundred miles~~ [of its course], ~~but beyond this point~~ opinions were very much divided as to the line which would be best adapted for agricultural [commonly] purposes, and my attention was directed to the following views which were entertained by the Agra Government on the subject of its extension.–

"The course of the canal below Roorkee or rather from the point in the Muzuffurnuggur District whence the Futtighur Branch will be thrown off, requires mature consideration. The primary object of the Canal is to be Irrigation and it is very doubtful whether the course which follows the water shed line down to Allahabad is that which most needs a supply of water for Agricultural purposes.– The Kalli Nuddi, the Eesun, the Pandoo, the Rinde, the Seyngoor, and the Kumaon each

"each have their rise in the plain
"of the Doab south of Roorkee, and
"after running for some time in
"a direction nearly parallel
"with either the Ganges or the
"Jumna, empty themselves into
"one or the other. - They thus divide
"the Doab into several longitudinal
"sections, the present state and
"actual capabilities of which are
"very different."

"This is peculiarly the case
"in the District of Cawnpoor
"which stretches across the Doab
"from the Ganges to the Jumna, and
"through the centre of which inter-
"-mediate between the two Rivers,
"the Rinde pursues its course.
"In the Pergunnahs (Division
of a District) between the Rinde
"and the Ganges, water is near
"the surface, wells are consequently
"numerous, and the country is
"rich and well cultivated. -
"Between the Rinde and the Jumna
"water is far from the surface and
"wells are constructed with diffi-
"-culty, the Country is exceedingly
"ill cultivated and poor. - There
"can be little doubt that a
"Canal for Irrigation is more
"wanted in the latter than in the
"former, and yet the plan as o-
"-riginally laid out contemplates
"throwing the largest supply
"of water into the former." -

"These circumstances regard-
-ing the Cawnpoor District are
"mentioned as illustrative of
the considerations which may
"influence the Course of the Canal,
"but are not to be considered
"as at all affecting the final de-
"-ter-

"termination which may be reached "after the country has been examined "and reported on by competent Officers"

The Surveys and Levels upon which the Projects which I had up to this period submitted to Government had been based, consisted merely of the examination of the tract of Country which might be considered the line of water shed between the great Rivers, the whole of the work with the exception of 2 or 3 cross levels which were taken in the Futtehpoor District, had been done by myself unaided by others of any description; the only lines therefore that had undergone the test of positive Survey were those from Hurdwar to Allahabad, with a Branch line to the Ganges at Cawnpoor, the Country towards the Jumna had not been examined, the Sketch that I had given of it was necessarily a general one, and ~~the~~ its evident necessity ~~that~~ existed of subjecting the Country, that ~~[illegible]~~ under the influence of the Canal whether on its main line, or on its branches, to a more detailed and comprehensive examination than I had been able to bestow upon it, ~~were questions evidently to be considered~~ previously to the determination of the precise direction to be ~~[illegible]~~ given to the ~~to which the Canal might be made advantageously [illegible]~~

There were also three questions which ~~at~~ immediately occupied my attention. To ~~[illegible]~~ ~~at that which [illegible] been above alluded to~~

Report

Report of the Medical Committee ~~and its inspections on sanitary points~~, although ~~in no degree affecting~~ the Plan of Excavation which had been proposed for the Main line and its branches, ~~led to~~ consideration on the best methods ~~to be adopted~~ for supplying the Irrigation Channels and ~~of determining in which way the heads of these channels could be most conveniently adapted to the works, a more deliberate inquiry as to the~~ position and number of Escapes as well as for regulating the water in its connection with the Branches, ~~was connected with sanitary questions and~~ depended a good deal on the results of the detailed surveys. —

The Channel Excavation which, as I have before stated, had been steadily in progress from the first commencement of our operations, ~~limited in the means that were placed at our disposal~~ had advanced far down the high land South of Roorkee, ~~as far as~~ The results of this Excavation ~~had been carried the results~~ had ~~been as regards~~ soil of a exceedingly unsatisfactory character the Clay subsoil which had been observed in a greater or less degree to be a characteristic feature of the Country, ~~turned out to be~~ a merely superficial ~~stratum~~ varying in depth from 3 to 10 feet, and overlying a deposit of (in many cases) purely River sand, extending apparently to an unlimited depth. — The Excavation

excavation which had up to this period been made had in fact removed the whole of the good, leaving the sandy substratum for the bed of the Canal. - As further inquiry and examination by excavations carried on in the more southern districts exhibited results equally unfavorable. My attention was directed to the inapplicability not only of the slopes of the Canal bed as originally projected, but to the design of the works generally, which with reference to their foundations, and to the means provided for their protection, were clearly inadequate to the contingencies arising from these unexpected ~~results of the excavations.~~

The points above noticed were brought under review at the earliest period possible; and the surveys and levels of the Country in the Southern Districts having been completed, and the direction of the main line and its branches having been determined ~~on~~, the whole of the works of the Main Line was in progress during the cold season of 1849/50. -

In 1850, at the desire of the Agra Government, I submitted a report with a revised estimate founded on data derived from 2½ years experience of the Cost of Labor and materials of the different districts and shewing the actual Amount of expenditure which ~~under the provisions of the Directions~~ above referred to, would be required to complete the works

The lining out of the ~~Canal~~ channel had

had at this period been devised ~~for the~~ as a best ~~contrivance for conveying~~ the water, and of delivering it over these Southern Districts, where from the difficulty in sinking wells, and from the depth at which spring water was found, its uses would be the most appreciated, and its benefits would be the most palpable.

The Main Trunk was carried in the direction proposed in the original Estimates as far South as the 180th mile, throwing off from the left a branch to ~~the~~ [illegible], and to the right a branch to the Bolundshuhur or [illegible] Districts; the former leaving the main line at the 50th and the latter at the 110th mile; between the 110th and 180th mile, and intermediately between ~~two~~ these two points, another branch not included in the original Estimates had been projected for the irrigation of the Country lying to the left of the ~~[illegible]~~ [illegible] River and to the Right of the town of Koel; this branch which left the main line on its right bank was intended to irrigate a tract of Country equal in extent to that of the Bolundshuhur Branch.

At the 180th mile, or at a point a few miles below the Town of Koel, the main line is divided into two Canals or branches of nearly equal dimensions; the one on the left leaving direct upon the Ganges near Cawnpore ~~and the Ganges River at that point~~, and the other upon the Jumna at a point near

near the commencement of the Alligpoor and Cawnpoor Districts; the latter keeping to the right instead of to the left of the Rinde River as was originally contemplated, and passing through the Districts lying on the Jumna side of the Doab. This arrangement ~~which~~ was consonant to the views expressed by the Government, and better adapted to the economical application of the water for the purposes of Irrigation.

In submitting my Estimate of 1850 ~~to the Government~~ it was prefaced by the following observations,

"There are three points which have "greatly influenced the designs "of the works now estimated for "viz:

1st The results of the proceedings of a medical Committee, which determined that the high water of the canal should be kept as much as possible below the surface of the Country.

2nd The results of Excavations in the upper Divisions showing that the supersoil only was clay, with an uninterrupted substratum of Sand.

3rd The Change of design in the distribution of the supply above the 110th mile, which in connection with the views above referred to have in fact led, with few exceptions to the total reprojection not only of the masonry works, but of the capacity of the Canal Channel.

"In referring therefore to the papers already

"already printed" I observed "that "the present may rather be con-"sidered a 4th in succession to "the 3 projects formerly submitted "than a Revised Estimate on what "was done before" -

As the alterations arising from the above considerations neces-sarily added largely to the Amount of Estimate, it will be satisfactory in this place without entering into the particular detail of each work which will be fully described hereafter, to give a general outline of the Changes which were proposed and of the effects that such Changes had on the different divisions

The 1st Division, as I have before explained, includes the whole of the works in the Khadir or low land of the Ganges, and extends to a point on the high land of the Doab about 4½ Miles distant from the Town of Roorkee with the exception of a more di-rect bearing upon the Rutmoo Torrent from that of the Rampoor the direction of the Canal align-ment in this Division was in close approximation to that of the original design. The works [illegible] the early part of its course as well as those on the Solani Torrent were with the addition of improvements arising from local circumstances also similar intermediately, however, between the Town of Jowallapoor and the Peran Kulleear ridge, great modifications had been made, not only in the slopes and capacity of the excavated Channel, but also in

in the design of the masonry works. It had been found necessary to carry the deep digging to points much further back than was originally intended, to enable the floods of the Ranipoor and Puttri Torrents to pass over and run independently of the Canal Channel, an arrangement which the enormous quantity of silt brought down by these Rivers appeared to render indispensable. The greater part of this excess of digging had to be performed under great difficulties arising from the height of Spring water, with the necessity of providing against the inroads of floods during the progress of excavation; the soil was of such a light description that foundations for the masonry works of a character not before contemplated, either in massiveness or depth, became a necessary part of the Estimate. The more direct bearing on the Rutmoo Torrent and a general consideration of the action of water upon a [illegible] of greater or less radius, together with more deliberate observations upon the Torrent itself, led to a complete remodelling of the works opposite to this River: masonry Revetments were projected upon the Curve of approach, and the foundations of the whole were designed of a much more massive description than those originally ~~contemplated~~ conc. The works on the Solani valley were with the exception of Terminal Cattle Ghats

Flats and a Bridge at the north to correspond with that of the south end, unaltered in Elevation; the foundations and floorings of the Masonry Aqueduct had been strengthened, and in consequence of Kunkur not having been found in sufficient abundance the use of Brick had been more generally practised.

With the exception of the first 2 miles of its course, the Slopes of the Canal bed had been revised and modified; superfluous slope had been disposed of at the Masonry Falls, and an additional fall of 8 feet ~~was~~ had been designed at the extreme end of the Division ~~at~~ near the village of Assufnuggur. Below Assufnuggur ~~and as far south as the 18th mile~~ the slopes of the Canal bed ~~were~~ had been reduced from 18 to 15 Inches per mile, ~~and~~ the superfluous slope ~~was~~ having been disposed of in additional Masonry descents or Falls of 8 feet in perpendicular height each, as far south as the 105th mile and beyond that point [illegible] by two falls of 5 feet each. The sandy nature of the soil, especially on the line extending from Roorkee to the 110th mile, rendered it advisable to extend the waterway of the falls which were built within these limits, so as to admit of the run of water over them being as little obstructed as possible, — for the same reason ~~an extension to the depths of~~ Foundations and floorings of a much more massive description and greater depths than those originally

originally estimated for, were con-sidered to be indispensable; the water way of Bridges was slightly increased their foundations strength-ened, and the usual means were adopted, for overcoming the dangers and difficulties attendant upon laying foundations in a sandy soil.

The number of Bridges which had in former estimates been fixed on a scale allowing one bridge to every three miles, was more determinately arranged on the actual wants of the country, the width of Roadway of Bridges was increased to meet the High Military, District, and Branch Trunk roads, and means of access to the Canal water were provided at all points where the convenience of the Community rendered such a course necessary.

At the point of departure of the various Branches works were provided for, by which the supply might be regulated ~~by~~ to the demand for Irrigation, or by which a Branch itself or the Main Canal South of that Branch might be laid dry, when ~~circumstances [illegible]~~ repairs, or [illegible] ~~[illegible]~~, might render such an arrangement necessary.

~~Heads for Irrigation were~~ In the upper portion and in the sandy tracts of the Canal, con-fined to the higher levels of the different Falls or descents of masonry; and in the lower dis-tricts these heads were attached to the different Bridges ~~of which they~~ formed a component part

of

of this design

1 ~~The line of Canal~~ It will be understood from the above detail that the C[anal] had been entirely remodelled, not only in depth & section to meet the 1st and 2nd Articles of the Rules that had been laid down for my guidance, but to meet the change in the distribution of the water which the alterations in the direction of the Branches in the southern Divisions had rendered necessary.

In ~~Concluding~~ this report I observed, that the expenditure which was included in the Estimate embraced not only that of the works themselves, but of all repairs and Establishments appertaining to the Ganges Canal from 1842 to the 30th June 1853 at which period, unless unforeseen accidents ~~occurred to retard it~~, it was supposed that the works contained in this Estimate would be completed; 2d pointed out that in the southerly Divisions, the masonry works had been placed on the general scale the proper working out of which would depend very much upon localities; that in many cases the estimated Cost would be in excess of the actual expenditure, that I had endeavored to include in this estimate the irregular works attached to the Solani in the Ganges Khadir, as well as at Hurdwar and in the bed of the river Ganges ~~Khadir~~, and that it had been my object to exhibit in one Connected Sheet the whole of the liabilities.—

Without laying any particu-lar

lar thus on circumstances which the times rendered quite unavoidable, I alluded to the many interruptions that had taken place to the progress of the works, since ground was first broken on the 16th April 1842, and to the Order of Government issued in 1846, giving to the Establishment and Laborers, both Hindoo and Mussulman, the Sunday in addition to the numerous holidays of their own particular Faith.—

The Total Amount of the Estimate of 1850, was as follows:

Total of Estimate for Works on the Main Line and its Branches	14160311	7	5
Total Expended on and Estimated for Establishments to 30th June 1850	1155930	14	11
Do. for Ordinary Repairs Do.	264733	3	0¼
Do. for Sundry Expenses	19824	14	9
Grand Total (Co's Rupees)	15605806	7	0¼

At the period that this Estimate was submitted or up to the 30th June 1850, the following Expenditure had been incurred.—

1st Division including Materials	2977731	10	5
2nd Do.	1397234	15	11½
3rd Do.	439434	2	"
4th Do.	156587	13	6
5th Do.	10382	15	8
6th Do.	69984	7	11
Director's Office	1[illegible]2750	13	"
Grand Total Expended to the 30th June 1850	5374111	14	9½

It would nevertheless, be a somewhat unprofitable task to ~~introduce~~ advert to the various interruptions to progress that had taken place since the 11th of January 1848, the date on which I re-assumed charge of the works, and the date figured in the above Estimate

Estimate. The second Sikh war deprived us, for many months, of the services of some of our most valuable Officers; sickness and other causes had led to the departure of others; but the Government steadily persevered in providing funds for every demand that we could make upon the public Treasuries; nor for a moment did the expenses of the Sikh war, nor the great demand for money, that such a concentration of forces must have called for, interfere with the expenditure on this great work of public utility.

The above Estimate was framed under the idea that the works included in it, would be completed in three years. There were however contingencies beyond those of the mere interruption from change of Executive Officers from sickness, or from the many other causes which influence the progress of works in general; the completion of the works in the Estimate, was in fact the completion of the works in the Northern Division, and the completion of these works depended entirely upon our success in Brick making; I have in the early part of this narrative, pointed out the demand that is made upon the Engineers' time and patience by the absence of the wealthy and respectable Contractors who in Europe go hand in hand with the Engineer; this absence throws the whole of the ~~detail of~~ material manufacturing and collecting into the hands of the builder who in addition to

his

his other numerous and respon-sible duties, has to manage the detail and keep the accounts of every Brick and Lime Kiln that supplies his work. ~~with material~~; The Executive Engineer in the Northern Division was relieved from this detail by the appointment of an Officer whose duty was confined to the Collection of Material. In the Southern Divisions, no ar-rangement of this sort had been entered into, and the Executives had to supply themselves to the best of their ability.

Mr Finn, the Executive Of-ficer in charge of the material Department of the Northern Division had by the greatest perseverance, and an energy not to be inter-rupted by disappointments, succeeded in establishing [illegible] on a large scale at four different points in the Northern Division ~~Brick manufactories~~; in which the Kilns [illegible] ~~the designs of~~ which had been brought home [?] by Captain Weller of the Bengal Engineers, ~~and with certain al-terations adapted to the particular circumstances under which they were used, and to the particular wood-cut~~ but altered to meet the particular circumstances under which they were used and the varieties of wood fuel which the forests in the neighbourhood produced. Suc-ceeded to an extent that had hardly been anticipated. In-terruptions arising ~~which had arisen~~ from strikes amongst the Brick moulders, upon whom Mr Finn had been for a long time depend-ant, had been completely put a stop to by the introduction of Brick making machinery

the

the model of which had been im-
ported from England; the diffi-
-culties in fact which had marked
the early part of our experiments
in Brick making had entirely
ceased, and a Cold weather fa-
-vorable to progress, or one moder-
-ately free from rain was all that
was required to secure the manu-
-facture of bricks in sufficient
quantities to enable us to com-
-plete the works in the Khadir
within the period calculated
upon in my Estimate.

The working season of 1850/
51, or that from the commence-
-ment of October 1850, began un-
-der very unfavorable auspices.
Lieutenant Fraser, the Executive
Engineer of the 2nd, and (as regards
the difficulty of the works) the
next in consequence to the North-
-ern Division, was unexpectedly
attacked by illness which render-
-ed his departure for Europe on
medical certificate a matter of
urgent necessity; the removal
of one of the Assistants of this
Division also ^at the same time ~~at this time~~ threw
the whole of the responsibilities
on the shoulders of ~~his~~ ^the remaining
Assistant, Mr Read, who totally
unaided had to carry on works
which were in active progress
on a line of upwards of 80
Miles

The Cold weather rains
of 1850/51 were ~~of a nature~~ un-
-usually severe, and from their
continuing ~~through a long~~
~~successive period~~ uninterrupted-
-ly ^for a long period were more injurious to the
Brick manufactories than had
they

they been more violent, and fal-len at detached ~~places~~ times - the effects of these rains were seriously felt throughout the whole line of the works, the quantity of bricks and brick kilns that ~~were~~ was destroyed in the Southern Divisions was very great; but the evil was felt more severely in the Northern Division where in all probability from its proximity to the mountains and forests the rains were more severe than elsewhere. For three weeks, or for 21 successive days during the most active period of the season and unfortunately at the early part of the cold weather, all at-tempts at burning or even ma-king bricks failed: the Brick fields were totally cleared out, the large parties of masons which had been collected in the hopes of an unfailing supply of material had to be broken up, and a great number of men had to be discharged.

The discharging of men of this class was a matter of very serious importance; the detached situation of Roorkee, and its position with regard to neigh-bouring towns, placed us in dependence on Oude, Rajpootana and the Country North of the Sutlej; to break up the parties of Masons, therefore, was tanta-mount to delaying the com-pletion of the works; the nature of our position, however, rendered such a step necessary, and although I have no doubt that had fine weather succeeded, the

effects

effects of these rains would have been in some degree neutralized by Mr. Irwin's activity, the season continued to be a most unfavorable one; and I have no hesitation in placing the delay that has occurred in the completion of the Aqueduct and the works in general, to this most unpropitious cold weather of 1850-1851.

The destruction of Bricks which were in fact the ~~post~~ first necessity to progress; the quantity of work yet remaining to be done in the 2nd Division (in the Executive duties of which Mr. Read had succeeded Lieut. Fraser) the impossibility of maintaining staff adequate to the efficient furtherance of progress determined me at this period to confine all my endeavours to completing the main line, and the two Branches into which it separates below Alliganh.

There were many reasons, laying aside the causes above described, why this step was a very desirable one: The nature of the works in the Northern Division, especially those connected with the great Aqueduct over the valley of the Solani River, appeared to point out the advisability of admitting in the first instance a moderate supply of water into the Canal, and to increase this supply gradually in a ratio proportionate to its effects upon the Channel and slopes. Whatever may be the knowledge at present possessed by our Canal Engineers, this knowledge is confined to dealing with comparatively

small

Small bodies of water, (the maximum being 2250 Cubic feet per second) and with Channels of moderate dimensions; it would therefore be unwise to commence on the Ganges Canal with supplies larger than we have been accus-tomed to ~~[illegible]~~, and whatever may have been the sanguine views either expressed or written on the subject of "at once throw-"ing over the surface of the Doab "the means of Irrigation"; a deliberate reflection on the nature of the works, on the knowledge we at present possess, and on the dangers that we should incur by any precipitate measures with regard to supply; satisfied me that to do justice to this great undertaking we ought in the first year that water is admitted to confine the supply to a min-imum i.e. to that which now runs in the Eastern Jumna Canal, that by the admission of so small a body of water, we should ~~shall~~ be able to observe its effects upon the Aqueduct and the Sandy tracts that lie in the Muzuffurnuggur District, and be able by observation to suggest and to apply remedies for counteracting any of the evils that may practically exhibit themselves. _The above supply would annually be increased under the advantages of a most useful experience and by the time that the supply had arrived at an amount equal to 4,4[illegible]0 Cubic feet per second (or to double the amount in the Canals west of the Jumna) which corresponds to the ~~is that which corresponds to the water~~ quantity required for the Main Line.

Line of Canal and its two tail Branches; and by the time that the consolidation of the Earthwork both at the Aqueduct and elsewhere had been perfected, and the stability of the Channel insured; the opening out of the Branches towards Futte-gurh and the Bolundshuhur and Koel Districts, the works of which would have been steadily going on during the above period, which we may call the probationary service of the Main line, would be effected with the greatest security, and with the most satisfactory results. –

I believe that the above is the soundest view that can be entertained of the Question, and that the objects desired by + Government will by following it, be the most certainly gained: but at any rate there ~~was~~ were at the period when the question of discontinuing the branches was settled, practical reasons of a sufficiently obvious character, why the works could not be done. There was a clear necessity for limiting the progress ~~of the works to~~ by the ~~means that were in the way of~~ Establishment. ~~these means were~~ [illegible] barely sufficient to enable us to complete the works of the Main line, a Consummation ~~which was~~ indispensable to the admission of water; and it would have been impossible, without defeating this main object, to have Extended our views in other directions or to have — — — — — — — divided our Establishments by undertaking additional works detached altogether from the Main line

line of our operations

The country over which the Futtighur Branch, which leaves the Main Canal at the 50th Mile, passes, had been accurately examined by Mr Dodsworth the Surveyor, its surface had been covered by a reticulation of levels, which left the determination of the line a matter of no difficulty; this line had been tested by a series of levels, approved by Mr Read; Bench marks had been established at every mile, and Brickmaking and Brick collecting had been steadily in progress in those Districts over which he was able to exert his control.

The Country over which the Koel and Bolundshuhur branches extend, lies in the 3rd Division; the estimated length of each of these lines is only 70 Miles; their direction and uses will be closely connected with the laying out and extent of the Rajbuhas or Main lines of Water Courses which will extend over that part of the Koel and Bolundshuhur Districts, toward the [illegible], and their direction will depend very much upon that of the Rajbuhas with respect to the tail discharges, and the connecting links which are in my idea of the Rajbuha system, one of the most indispensable elements —

The projects for these different lines as far as capacity of Channel and Bridge water ways are concerned having been accurately determined, the excavation and Masonry works can be carried on as soon as a supervising

Surmising Establishment is available for the purpose. I have in fact shewn that some progress has already been made on the Enfranchise Branch, not only in laying down the line, but in collecting materials. On the Belundsmun Branch six miles of the Channel has been completed and some small progress also has been made in material collecting.

The disappointment arising from interruptions to progress which ~~(in the credit of my Estimate of 1850)~~ so unfortunately took place during the cold season of 1850/51, was in some degree alleviated, by the results of the succeeding years; the seasons of 1851/52 and 1852/53 were marked by an uninterrupted and steady advance ~~to progress~~ in the Northern Division on a scale that could not have been exceeded, and although very considerable additions had been made to the ~~works~~ [illegible], by which the amount of work to be executed was increased, the improved organization of our Establishment and the increased means at our disposal in the shape of "Plant" placed us in a position which at the close of the season of 1852/53, enabled us to arrive at satisfactory conclusions as to the period when the works would be sufficiently advanced to allow of the admission of water. –

In my Estimate of 1850 the above period had been fixed at a date early in 1853/54, or by the termination of the Month of June

June 1853, the causes why this had not taken place have been sufficiently described, but it is satisfactory that under the necessity of making these explanations, and under the interruptions which led to such necessity, we find that the work of one season only in addition to those formerly contemplated has enabled us to bring these gigantic works to a conclusion at the end of the year, I use the term conclusion, as although a good deal still remains in finishing off the Masonry and Earthworks, and to the fixings of the Dams, the line of Channel throughout the Northern Division has been brought to that state in which the supply of water can be passed to the Southern Districts, and from whence may be dated a new era in the history of the Ganges Canal.

The works, however, on the Etawah Branch which were commenced at a later period than those elsewhere and which have been much retarded by want of European Establishment will at the period above mentioned be incomplete; they will be ready to receive water on the first Sixty Miles and the Sihur Escape which is situated at the extremity of that distance will admit of a Stream being passed down the Channel. On the Cawnpoor Branch with the exception of the Locks into the Ganges, and the Terminal works in and near the Town of Cawnpoor, the whole line will be ready to

to receive water, which may be passed off in the meantime at the different escapes which are situated at ~~distances~~ intervals down its course; the works here have been retarded by the departure ~~on sick certificate~~ of the whole of the Staff of the 6th Division in which the Cawnpoor works were situated, the consequent breaking up of the Division, and the often told tale of "want of materials".

Amongst all the disappointments, that have arisen either from the removal of Officers to higher appointments, or to the departure of others on medical certificate, by which the advancement of work has been more or less impeded; the Staff of the Northern Division has remained intact, without changes excepting by additional members and with as little interruption from sickness as could reasonably have been expected; it would be useless to expatiate on the advantages that the works have derived from an occurrence which considering that the time alluded to extends through six years is a very unusual one; it has however given to each work the inestimable benefit of having been carried on through all its progress by the same individuals, and it has given me the benefit of an uninterrupted connection with a Staff of Officers who from the highest to the lowest have devoted their undivided attention to the interests of the great works upon which they have

been

been engaged. The names of the Officers who composed the Ganges Canal Staff on my joining the works in 1848, were given in a former paragraph; I will close this Chapter by giving the names of those who were present at the works when the Canal was opened

1st Division Captain A. G. Goodwyn, Engr
Lieutenant G: Price
Mr J: Parker
" J: Login
" W. Kay
" C: Anderson
" Wm Rogan
" J.C. Kay
" J: Finn
2nd Division Mr J. Read
[illegible]
3rd Division Mr P. Volk
Lieut Merrick
[illegible]
4th Division Lieut C. J. Hodgson Engr:
Cawnpoor Branch " Lamb
" Willoughby spe-cially for the Cawnpoor works

5th Division Lieut J. Whiting, Engr.
Etawah Branch " Brownlow "
" Angelo
" [illegible]

The 6th Division which during the season of 1852 had been deprived of its Officers, (the Executive Engineer and One Assistant having gone away on Medical certificate, and the remaining assistant having been removed to a higher appointment in the Road Depart-ment

=ment) had been incorporated with ~~to~~
the 6th Division, [illegible] the whole of the
Cawnpoor branch having been placed ~~being~~ under the
management of [illegible] ~~the same Officer~~

Mr Dousworth who besides
some very useful surveys in map-
=ping the details of the very in-
-tricate drainage of the Country
through which the Cawnpoor
Branch took its course, had
completed the whole of the Surveys
and levels of the Country lying
between the Ganges and the East
Kali Nuddi, as well as that portion ~~and~~ the Jumna
and Rinde, the sections of the
Doab which were to be irrigated
by the Futtegurh and Etawah
Branches; was at this period
engaged on a series of levels for
working out a Contour of the
Ganges Khadir, or ~~in~~ that portion
of it which lies to the North or East of
Roorkee, [illegible] between that place
and the Sewalik mountains;
an undertaking requiring ex-
=traordinary care patience and per-
-severance, and one of the high-
-est importance, as conveying
by the most careful delineation
of minute topographical de-
-tails, the fullest information
on the drainage which crosses
the Canal works ~~North of Roorkee.~~
in the region under examination

PART, II

PART II

Topography of the Country & Description of the Works

CHAPTER I

Prefatory Remarks

The Canals for Irrigation which have hitherto been constructed in these Provinces, with exception to the water courses in the Deyra Doon and Rohilcund, were supplied exclusively from the River Jumna and consisted [illegible] ones on the right bank, of the irrigation of the Hurreeal, Paniput, Delhi, and the Districts to the westward, the other on the left bank, of the irrigation of the [illegible] Districts lying on the right bank of the Hindun, between the hills and Delhi.

The Country at the foot of the [illegible] is crossed by numerous Mountain Torrents which the above Canals intersected, under circumstances of remarkable difficulty. It will be interesting therefore to give a sketch of these peculiarities of surface and of the profile of the country [illegible] preparatory to entering upon the description of the Ganges and its drainage, the subject to which this Chapter is more especially directed.

In [illegible] the Maps the direction of the Jumna from the point where it leaves the Hills to Delhi, and showing the position of the Eastern and Western Jumna Canals with their

~~Sources~~ heads of supply opposite to each other, their ~~lines running~~ alignments parallel and their Escape or tail water joining the Parent Stream at points also opposite, an indifferent observer would naturally con~~sider~~clude that under ~~such~~ coincident ~~circumstances~~ circumstances so strikingly ~~any~~ such difficulties ~~of~~ as were due to surface colour would be common to both, and that the works required for the maintenance of one Canal, would (~~supposing~~ in some particulars ~~the capacities of both Canals to be the same~~) be similar to those of the other.

~~In the Central and Southern regions there is a considerable correspondence between the levels of both Canals; the steps which occurs into the Khadir near the village of Humrouli on the Eastern Jumna Canal, and which is passed by a succession of Falls and Lockage is on the Delhi Canal maintained on the high level into the City by which means an ample supply of water is provided for the Inhabitants; the rapid descent into the Jumna takes place almost immediately at the end, the greater part of the tail water passing through and turning flour Mills, and the whole escaping over paved and well protected Channels into the River.~~

In the central & Southern regions the levels of both Canals correspond generally with each other. On the [illegible] bank however the limit of the river or Khadir is thrown back as far as the [illegible] of Humrouli on the Eastern Jumna Canal a distance of about 12 miles from the end of the stream, & the slope thereby caused passed by a succession of Falls & locks. On the western bank the high land [illegible] the Khadir is maintained up to the immediate vicinity of the city of Delhi; the Western Jumna Canal is enabled to provide an abundant supply of water for domestic [illegible]. The rapid descent into the River itself takes place virtually at the [illegible] of the Canal, & the fall thus obtained is [illegible] for flour mills, worked by the [illegible] water for which an Escape into the River is provided, through paved & well protected channels.

It is in the Northern region ~~we would~~ the [illegible] we observe the greatest difference. On the west of the Jumna, the Canal on its leaving the Parent Stream passes over wide and open beds of shingle, upon which the ~~stream~~ force of the current is able to exhaust itself; these ~~shingle~~ beds extend ~~to a distance of 16 miles~~

as

as far South as the Dadoopoor Dam, [to a distance of 16 miles] and during the whole of their course are the receptacles of the Country drainage, which passes off during floods either over the Country or through breaches which are repaired annually after the rainy months. The Dadoopoor Dam which regulates the supply into the Canal Channel, [is also the means of] ~~passes off~~ the flood water of the Putralla and Sombe, the latter being a Torrent of very large dimensions. From the ~~Dadoopoor~~ Dam the Canal proceeds along the lowland ~~and continues on these levels~~ until it reaches a point 60 miles from Dadoopoor, at which it [first] ~~gradually~~ gains the levels of the high country, ~~on which it~~ continuing [from its deflection] to the [illegible] on its left, and to Kansi on its right branch.

Although careful Masonry works are provided on this Canal for the passage of the Putralla and Sombe Torrents, the [illegible] [its first] 60 miles of its course [are] ~~being~~ ~~[illegible]~~ in the Khadir or low lands of the Jumna ~~River~~ through which [the channel] ~~it is allowed to~~ wanders with all the tortuosity of a natural River, and [the rest of that] ~~the part of~~ the whole line after its escape from the Shingle beds, ~~being~~ out of the influence of the rapid slopes which are natural to the proximity of the mountains, render the [occurrence] ~~passing of~~ of floods even of an extraordinary [volume] ~~nature~~, a matter of comparatively little moment. Leaving out of the Question the Putralla and Sombe, floods do in fact pass directly over the course

of this Canal ~~with~~ on the tracts both above ~~and those~~ below Dadoopoor, without doing any material injury either to the ~~Canal~~ works, or to the Country.—

The Eastern Jumna Canal the ~~head of which is opposite to that on the west~~ after passing down the Shingly bed of the Boodhee Jumna for the short distance of 11 miles, [illegible] takes a South Easterly direction, ~~in deep cutting which~~ commencing at the village of Nyashuhur; from this point it plunges at once into all the difficulties ~~that attend upon~~ incidental to a line crossing mountain drainage at right angles to its course. The Raipoor, Tatonwala, Nogong and Mushkurra, four mountain torrents of greater or less dimensions are passed within a distance of 10 miles from the Nyashuhur deep cutting. The Mushkurra and the Nogong are torrents of considerable magnitude, and are provided with masonry Dams for the passage of floods during rains. After passing the Mushkurra, the Eastern Jumna Canal Channel continues on the high land of the Country.

With a similar declivity therefore on both the Eastern and Western Jumna Canals between their terminal points, its distribution in detail ~~of this declivity~~ leads to most remarkable differences in the requirements for works. The great Northern step which on the Western Canal is passed by a succession of wide beds of Shingle,

with

These [illegible] beds [illegible] ... [illegible] on the high land of the [illegible] ... [illegible]

with considerable tortuosity on Channel through low or flat country, is on the Eastern line maintained for many miles on the high land in the face of numerous mountain torrents, and finally overcome by a succession of masonry falls. The extent of the shingle beds off the west of the Jumna Channel, points out the comparatively easy way in which this defect of country is passed on the Western Canal on that side of the Jumna, and explains at once the absence of any necessity for the local descents or expensive works for overcoming the excess of slope in accounting in opposition to the necessity for such works on the Eastern Canal, where the object common to both, had to be accomplished under such different circumstances.

The works on the Delhi or Western Jumna Canal were ~~partly~~ designed partly by Capt. Blane of the Bengal Engineers, and partly by Colonel Colvin C.B., of the same Corps. Those of the Eastern Jumna Canal were designed by Colonel Robert Smith C.B. of the Bengal Engineers, on these latter works my early career as an Officer of the Canal Department was passed, I joined ~~them~~ Col. Smith in 1825 shortly after the works were commenced ~~in 1825~~ and superintended the opening of the Canal in 1830. -

The mountain torrents ~~which~~ ~~[illegible]~~ connected with the Eastern Jumna Canal have naturally been the impedimenta to regularity of supply, as well as to the repose of the Superintendent, but time

and

and experience have ~~[illegible]~~ the Establishment ~~[illegible]~~ command over them, ~~and~~ the constant attention that has been given to their vagaries, and the application of remedies when such were required, have reduced to a matter of simplicity ~~that which~~ in the early days ~~of the history~~ of the Canal was considered by no means of a simple nature.

~~There was~~ One very remarkable feature in the Topography of the Country over which the Eastern Jumna Canal passed, ~~which~~ will give at once a key to the general remedies that were at hand for ~~[illegible]~~ difficulties due to the torrents and as these were remedies which were not always to be found when projecting Canal alignments, I must allude to them here, in anticipation of what has to come hereafter.—

From the description before given of the direction taken by the Eastern Jumna Canal on its leaving the parent stream, and entering upon the highland at Nyashunir, it will be observed that the very circumstance of the line of Canal running at right angles to the drainage of the mountains and consequently in a direction parallel to those mountains, shewed that the country sloped from West to East, and therefore that although the mountain drainage in its natural state crossed the Canal line, we held

the

the power in our hands of changing the course of this drainage at points lying above the Canal Channel, and by passing the water off to the Eastward, relieve the works from a great deal of the enormous [illegible] to which they were naturally subjected. —

A leading feature in the original project ~~in the location of these works~~, was the neutralization of the effects of the [illegible] thus exerted upon the works at Kulsea, by taking advantage of this natural arrangement of slopes and by turning its waters to the Eastward, ~~and~~ to connect~~ing~~ them at three different points with Rivers which were tributary to the Nerdun; the effects of these arrangements have been to reduce ~~the stream of~~ the Muskuma at its point of contact with the masonry Dam at Kulsea, to a comparatively inconsiderable volume. The Satonevalla drainage has on the same principle been turned into the Nogong River; at times the violence of a Nogong flood has been relieved by allowing a portion of its volume to pass ~~off~~ down the Canal Channel towards the Muskuma; ~~and~~ The [illegible] ~~consequence~~ of these arrangements of surface drainage [illegible] described thus [illegible] ~~but in the case of the tunnels connected with the works of the Eastern Tunnel Canal~~ have been undoubtedly of the highest importance and value to the works of the [illegible] canal. —

It is ~~under the~~ with some peculiarities

of

drainage ~~which I have above described~~, as affecting the works in the Northern District of the Eastern Jumna Canal, ~~and~~ which in itself ~~constitutes~~ the western watershed ~~drainage~~ of the Northern Doab and with the details of this ~~tract~~ tract of Country, fresh in recollection, that I would turn the reader's attention to the Eastern watershed, or the drainage which flows towards the Ganges River. The line of separation is well defined, the western drainage including the West Kalli Nuddee and its tributaries flows into the Jumna, the Eastern including the East Kalli Nuddee and its tributaries flows into the Ganges: the point of separation in the Sewalik being the Shahjehanpoor and Kotingraowin Passes, to reach which from the plains ~~there is~~ a Section of Country free from cross drainage [illegible], this Section ~~is~~ being in fact the back bone of the Northern Doab. –

It will be observed by referring to the map that from the point of watershed or from that ravine in the Hills which supplies the most westerly tributary of the Solani River, there is a bank which extends in a South Easterly direction, increasing in departure from the Hills, as it proceeds onwards; upon the edge of this bank are situated the Towns of Bhugwanpoor, Roorkee, Jowassi, Landoura, Noornugger, and on and near its approach to the Main Stream of the River ...

The

the Towns of Bhookunkeri and Sookuntal.. These Towns overlook as it were an extensive valley, the maximum depression of which must be very considerable; ~~but~~ Opposite the Town of Nur-nugger and at the village of Badshahpoor, ~~in~~ which my line of levels of 1836, ~~was taken~~, this depression was found to be [illegible] feet.. This tract of country ~~which~~ ~~is~~ bounded by the Sewaliks and the high bank above described receives the whole of the hill drainage from the western extremity of the watershed; this drainage is in fact restricted to the above limits by a well defined barrier. To the west of the high bank ~~and to the line of Towns situated thereupon~~, the drainage of the Country passes off by ~~the deep~~ shelving tributaries to the West Kalli Nuddi and ultimately to the Jumna River. A series of Sand Hills (provincially termed Bhoor) is here a remarkable feature; these ~~sand hills which~~ shew themselves in undulating elevations and depressions running parallel to the drainage of the West Kalli Nuddi ~~[illegible]~~ ~~[illegible] drainage, or~~ are found in ramifications thrown off from the main line, pierced at points to admit of the passage of the side drainage ~~and~~ occasionally ~~shewing themselves~~ in extended and ~~in~~ unbroken ridges. The slope of the Country is from the edge ~~Top~~ of the high bank towards the westward, and strange as it

may

may appear the watershed line of the Jumna and Ganges runs directly along the top of the ridge on which the towns are situated.

The tract of country which I have ~~above~~ described, ~~and which~~ is that portion of the Ganges Doab, with which the works of the Canal are connected. ~~It will be understood to be~~ It is of a triangular form, bounded on the North East by the ~~chain of hills called the~~ Siwaliks, on the South West and South by a steppe or bank, and on the South and East by the Ganges River. The Siwaliks on the North East, and the bank which lies on the South West and South ~~terminate in~~ [illegible] an acute angle ~~at~~ near the Tajubarpoor and Khoojnowur [illegible] ~~in the [illegible] range of hills~~. The bank as I have before described, diminishes in abruptness ~~[illegible]~~ [illegible] until it is lost entirely. The Doab receives the whole of the drainage up to this ridge, which is the true [illegible] watershed separating the drainage of the Jumna and Ganges Rivers. The depression of the triangular ~~tract of country~~ [illegible] is by no means uniform. To the westward there is an isolated [illegible] ~~tract~~ considerably elevated, on which are situated the towns of Khair [illegible] and numerous villages. The ~~tract in question~~ [illegible] is much intersected and cut up by Channels

channels, and it is separated, or nearly so, in its centre, by a large ravine receiving a portion of the drainage collected in the forests. In addition to this main insular tract of high land there are other smaller mounds in detached or outlying positions, upon which villages have been built. The town & village of Goorhut poor [illegible] is thus situated, and to the North of Goorhutpoor these mounds or knolls appear to be ramifications from the main levels (lying at the end of the hills) [illegible] which ~~[illegible] the surface of the country~~ ~~is~~ much elevated. The drainage is well marked, and may be divided into three distinct [illegible] ~~lines~~, the most westerly one embracing ~~that of~~ all the hills & country lying to the North of Kheri and Shah Munsoor, including the drainage from mountain torrents ~~extending for~~ a distance of 3 miles from the western angle; this [illegible] which is by far the most extensive, [illegible] ~~[illegible] along the [illegible] of the~~ [illegible] ~~[illegible] under the [illegible]~~ [illegible] ~~[illegible] River~~ reaches the Ganges in the neighborhood of Rookhu[illegible].

The second or central ~~line~~ [illegible] is ~~that of~~ the Ruthmoo River, the heads of which ~~rise~~ are in the neighborhood of Shah Munsoor; this River receives the ~~drainage~~ [illegible] ~~of~~ 11 miles of mountain, and is a tributary of the Sani, which it joins under the town of Jowalassi.

The

The third is the Puttri ~~[illegible]~~ Rao which receives all the water from the Country, between the Towns of Gurh and Towallapoor with a hill drainage of ten miles. The drainage of the Puttri ~~[illegible]~~ however, is in the earlier parts of its course divided into two distinct Mountain Torrents, the one to the westward being 'par excellence' the Puttri, that to the Eastward and in the neighbourhood of Towallapoor being called the Ranipoor River, ~~at this part of their course~~. These two branches, as they may be designated run in separate, although ~~[illegible]~~ ill defined basins, ~~they are~~ to all intents and purposes distinct Torrents, and as such have been separately treated.

To the Eastward of the Puttri drainage, or rather to the Eastward of that drainage connected with the Ranipoor River, and the Town of Hurdwar, ~~at which latter point~~ the Sewalik Hills infringe upon the Ganges River, there is a good deal of scattered drainage, which during heavy rains comes down with considerable rapidity from the low spurs and ridges which lie at the foot of the Sewaliks; the water derived from this source passes directly into the Ganges through numerous small channels which lie to the South of Hurdwar and Kunkhul. —

The Solani and Rutmoo Rivers, ~~which are supplied by the drainage of the Country to the~~

~~the westward~~, exhibit in their course under the bank at Bhugwanpoor and Roorkee, unmistakeable marks of their mountain origin. They are 'Raos'* in the most extended sense, with wide sandy beds, and although during exceedingly dry seasons, showing no external stream, having under a dry sandy surface, perennial spring water.

The Puttri and Ranipoor Rivers, ~~and those which are connected with the Puttri drainage~~ differ very materially from those above described. The map which shews in detail the courses of all the hidden drainage will give a better idea of the nature of this drainage in the direction of its different channels than I can give in description. In the proximity of the Hills, ~~however~~, they exhibit the character of well defined mountain torrents, with shingly and sandy beds, ~~[illegible]~~ which they [illegible] ~~[illegible]~~ [illegible]

---

* Rao (Roving Torrent) a provincial name given to the shallow sandy or shingly beds directly connected with the Hills, the drainage of which is carried off by these channels. During the greater portion of the year they are either perfectly dry, or with a small stream running in them. After heavy rain they are liable to sudden freshes and floods, and at the time are impassable for man or beast. The great declivity of [illegible] which they run enables them to pour out a volume of water with immense and dangerous velocity. These floods, however, do not last above a few hours, and subside as rapidly as they commenced.—

themselves only at [illegible] [illegible]
~~almost entirely lost in the absence~~ [illegible]
~~of all marks of watercourse by~~
~~appearing in detached bits scat-~~
~~tered here and there over the sur-~~
~~face of the country~~. In a more
Southerly direction these detached
bits of drainage become united
into One perfect Channel, which
[illegible] the Pullin Forest, wanders
ultimately over the lowlands,
and joins the labyrinth of Rivers
which intersect the Khadir at
its South Eastern extremity..

In further illustration of the
~~Character~~ Geology of the country, which
so much necessarily must be
said in explanation of our
proceedings, I may observe
that although Spring water may
be and is even at the hottest
periods of the year, found near
the surface ~~at~~ in the immediate
~~foot~~ of the Hills, it is one of the
characteristic phenomena of
the line of country ~~which lies~~ near up to
~~at the foot of the~~ [illegible]
that on a belt extending to an
irregular width ~~which lies~~ South
of and parallel to the Hills,
water is only found at consider-
able depths, whereas at points
lying beyond this belt, Spring
water either appears at the Sur-
face or is procured by very moderate ex-
cavations. In exemplifica-
tion of the above, although
somewhat anticipating the
Events which I am about to
describe, it was found that in
all our excavations lying
within a moderate distance
~~at~~ from the foot of the Hills, neither

Spring

spring water nor any appearance of spring water exhibited itself; as we got further into the hills and [illegible] our approach to the Rutmoo valley, spring water also became an evil of very serious importance; the Banstal from Nullah, which ~~is a tributary of the Rutmoo,~~ ~~and which rises to the west,~~ ~~[illegible]~~, was in fact a perennial stream. ~~[illegible]~~ The ridge between the Rutmoo and the Solani River was by no means free from an inconvenience, which we did not ascertain until we reached the excavations on the high land at Roorkee. The evils which arose from the interference of springs were really ~~in accordance with those which~~ we had anticipated; and although these evils became very much enhanced by the necessity of altering my original design which had comparatively speaking avoided the inconvenience of deep digging in the tract connected with springs; the difficulties that we met with did not after all exceed our expectations.

With the exception of that immediately in the neighbourhood of Kunkul and Hurdwar, the whole of the Country lying at the foot of the Sewaliks, and at the head of the Rivers above described was at the period of my original survey under

forest

forest and uncultivated, and although the triangular tract which I have described under the name of the Khadir was neither wanting in villages nor population, the greater portion of it was jungle and marsh; of the latter there were very extensive tracts connected with the Puttri and situated centrically and to the eastward of Aj Tub Shah; ~~[illegible]~~ with the Vlam and Bhut rivers and under the names of the Dogin and Jheel, covered a ~~very extensive~~ area of country near 12 or 14 miles, ~~and~~ at the time ~~that~~ I talk of was supposed to be inaccessible, as it was certainly avoided by those who visited the Khadir on tiger shooting expeditions.

By a tolerably accurate idea has been given ~~in~~ the above detail of the prominent features and character of the Jungle Khadir and of the mountain torrents which flow through it, I shall be able I hope to render an account of my operations, in laying down a line of Band ~~[illegible]~~ in a way sufficiently distinct ([illegible]) to be ~~[illegible]~~ perfectly intelligible.

I commenced my examination of the Khadir ~~[illegible]~~ in 1836, taking a section on its southern limit at Nausual pur and Kumiswu ~~[illegible]~~ the latter being a fixed point or bench mark situated on the top of the high bank which

and

I have described the South western boundary of the low land, I determined on obtaining a similar section on an extreme northern limit and for this purpose, ~~carried~~ a line of levels from a point on the Ganges between Hurdwar and Kunkul, touching the towns of Bhes and Pur and continuing down the high land by Bhugwanpoor, Roorkee and [illegible], until I arrived at the Rumbhera bench mark; this gave me an uninterrupted scale of 34 miles; intermediate levels across that portion of the Khadir lying between Bhes and the villages eastward of Roorkee, brought the whole profile and its capabilities for canal purposes distinctly under review. The result in fact shewed that there were two lines open for adoption, viz. One on an extreme circle by which the bed of the canal, would be maintained on a level corresponding with the surface of the country; the other, a more direct line which, crossing the valley of the Solani River, by an Aqueduct, would deliver the water on the high land of the Doab immediately at the town of Roorkee.

For the circuitous line we had the example of the Jumna canals before us, where the stream when crossing the beds of mountain torrents was retained by Dams and with sluices for regulating, and passing off floods; and we had in its favor the comparative security of keeping to the earth's surface, instead of carrying the canal water at levels so elevated above it; in opposition to these advantages which are to a certain

degree

degree admitted, we had the evils of a more extended course, through a wild and broken forest country with drainage very much divided, very much scattered, and with the certainty of that species of inundation which necessarily attends the Dam system. It was impossible to calculate on the extent of the inundation that would be incurred by this circuitous route, but it would occur on the upstream side of every Dam, and of these there could not be less than five, the whole of which would be situated at points where the great declivity of bed of the different mountain torrents over the course of which they would have to be built, would necessarily it was supposed, lead to all the evils of retrogression of levels in their beds, of which we had had dangerous experience in the works on the Eastern Jumna Canal. The objectionable influence in a sanatory point of view, that the introduction of so much inundation would exert upon the neighbouring country was by no means the least effective in leading me, and ultimately those who were called to give their opinion on the subject, to reject this Circuitous Line.

The direct route which was confined to the more civilized part of the Khadir passed the Rutmoo River immediately to the west of Peeran Kulleer, and bearing ~~upon a~~ directly ~~on a~~ upon Roorkee, reached the Solani valley at a point between the villages of Bajoheri and Mahewur; from this point to Roorkee which was

on

on the high land of the Doab the breadth of the valley was 2¾ miles and its maximum depression below the estimated bed of the Canal was twenty four feet. The objections to this course were first of all the novelty and probable danger of a design which contemplated the transport of a large body of water at high levels above the surface of the Country; and secondly, the expense which would undoubtedly be great; ~~as to the compensation~~ to counterbalance these objections however, we had the advantages of ~~escaping from~~ avoiding inundation; of maintaining a line through a more healthy and accessible Country; of keeping the Canal in its passage over the Solani free from the sand and silt, which ~~is an~~ inherent evils where a Canal comes in contact with a mountain torrent; and of being able to maintain an ~~open~~ uninterrupted line of communication across the Solani valley in connection with the more northerly works.

Even on this direct route which appeared to be in every way so superior to the other, the Rutmoo River ~~was~~ had to be passed by the Dam system, as obtains on the Jumna Canals. It was concluded however that there would be no difficulty in so designing the works as that the evil of inundation on the upstream side might be got rid of, by retaining the Canal water in its own channel, and ~~to retain~~ carrying the drainage which during the dry months comes down the River, or ~~that which arose from~~ is caused by leakage

leakage ~~and escape~~ from the Canal
Channel, ~~by constructing~~ drains
under the Canal, so that the water
might pass ~~at~~ down the course
of the River! The profile of the
Country was favorable to the
adoption of the Aqueduct system
over the Rutmoo, as well as over
the Solani, and the advantages
attending such a plan in carry
-ing the Canal water free from
the Silt and Rubbish of the Rutmoo
Torrent were much in its favor,
but very extended lines of Earthen
Embankment are not only very
expensive in the first instance,
but require much subsequent
looking after, entailing upon
the Government a large Establish
-ment for their supervision; the
Masonry portion of the Aqueduct
which would necessarily be over
the Rao itself, would from the
difficulties of foundation be equal
in expense to that ~~of the building~~
over the Solani and there was
no object in ~~retaining~~ the levels
of the Canal bed, over the valley
of the Rutmoo, as the natural
Slope of the Country in advance
was sufficient for all the purposes
of the Project, and to have con-
-tinued the high levels ~~over the~~
~~Rutmoo~~ would have ~~merely~~ led
to the ~~necessity~~ of a series of Falls
on the Pieran Kulleear [illegible] in-
-termediate between the two Aque-
-ducts. A Dam therefore on the
principle of those used ~~on~~ the
Tonse and Mushkurra Rivers
on the [illegible] Canals, was finally
~~determined on~~ for the Rutmoo
~~River~~

The project that I submitted
at this period was accompanied
by-

in a report, in which when discussing the merits and demerits of the two courses ~~which were~~ open for selection, I gave my reasons for preferring the line bearing upon Roorkee and crossing the Solani valley by an aqueduct. As the project and Estimate which were at that time submitted were on a very small scale and were drawn up simply with a view of establishing the fact that a remunerative work might be constructed, there appears to be no object in drawing any further attention to them; they were however, the basis upon which the Committee which was ordered to report on the project, ~~determined~~ devised their plans, and the line ~~that I had~~ adopted by in the original project was in every respect the same as that which the Committee selected. To meet the desires of Government, and in accordance with the views ~~that~~ I had ~~put forward~~ expressed in the report above alluded to, the Committee in looking to the Irrigation of a more extended tract of country, deemed it advisable to increase the head supply ~~then amount equal~~ to 6750 cubic feet per second ~~and consequently~~ [illegible] to increase the capacity of the canal excavations, and to extend the dimensions of the works. The result of this decision and the approval of Government to the recommendations of the Committee, led to my Report and Estimate of 1845, to which especial allusions have been made in a former Chapter.

Without

Without, therefore, entering into any description of the works of the former estimate, it will be sufficient, as the line of Country ~~for~~ for which they were projected was precisely the same, to review in detail the works that have been constructed, ~~to explain the causes of alterations to these works~~, and in as succinct a manner as possible to [illegible] the reader acquainted with the peculiarities of the surface of the Country upon which they have been executed. –

With this view I shall in preference to wearying the attention by tedious and unbroken descriptions of country, and works extending throughout the whole length of the Canal, diversify the subject by separating the detail into three Sections, each of which contains in ~~themselves~~ itself peculiarities of a sufficiently marked order, to render such a division not only convenient, but valuable and [illegible] ~~in some degree more appropriate~~ to distinct explanation

The three great divisions which naturally arise under the above view of the Question are:

I The Ganges Khadir, extending from the Ganges River to the high land of the Doab at Roorkee; the length of Canal Course being in this Section 19 miles –

II The Country from Roorkee to Nanoon marked by great declivity of fall in the surface and by its connection with the Bhoor or sand tracts;

the

in [illegible] at the land on this [illegible] being 163 miles —

iii. [illegible] from [illegible] the [illegible] and Jumna Rivers, marked by a deficiency of fall in the surface of the Country, and by its connection with the Hindan, [illegible], [illegible], and other Rivers which drain the flat lands over Central Districts. The length of the canals on this section being 385 miles

CHAPTER II

[illegible] Alignment and [illegible]

I

I "The [illegible] ~~m~~ [illegible] extending from "the Solani River to the [illegible] "and to the Ganges Canal works".

The main stream of the Ganges, the discharge of which is estimated in the driest months of the year at [illegible] cubic feet per second, after passing through the valley of [illegible] opens upon the plains of India by a well defined gorge, or as it may be termed a natural breach in the Siwalik mountains, immediately on the Right, and close at the foot of these mountains ~~is~~ are situated the Town and Temples of Hurdwar, On the left is the Chandni Ghat, a hill of a remarkably picturesque outline, on the top of which is a temple, and place of pilgrimage connected with Hurdwar itself. The River may be said to occupy the whole of this space, the width of water at its narrowest point is about one ~~mile~~. [illegible] all [illegible] ^(mountain) Rivers, however ~~[illegible]~~ ~~[illegible]~~ when they are in immediate Connection with the Mountains

Mountains, where their beds ~~are~~ ~~made up of~~ shingle, and ~~where the~~ declivity ~~of bed~~ is great, this wide expanse is intersected by numerous Channels, separated by well wooded Islands, many of which are placed beyond the reach of high flood water, and ~~many of them~~ partially cleared by the labor of the husbandman. A branch which was formed by an Island or Islands of this sort, passed directly under the Town of Hurdwar, and proceeding onwards ~~in~~ a tolerably even and unbroken section, rejoined the Main River at a point below Kunkhul, ~~another~~ ~~and~~ a large Town ~~[illegible]~~, situated about 1½ miles below Hurdwar.

The Main ~~stream of the~~ River which runs under precipitous banks ~~[illegible]~~ along [illegible] ~~closely~~ on the left, throws out on its right and within a distance of 2½ miles above Hurdwar a ~~branch~~ [illegible] of considerable importance, which under all the fluctuations that ~~attend upon~~ [illegible] these constantly varying beds, appears to carry, and to have carried for years, a very uniform supply of about One third of the whole volume. From this branch the Inhabitants of Hurdwar and Kunkhul have been in the habit of bringing a water course for the purpose of supplying the Towns ~~with water~~, the priests being interested in ~~obtaining a water~~ [illegible] supply for their ghats or bathing places, the community in general depending upon this supply for water both for drinking and for culinary purposes

-poses, for turning Corn mills, and to a moderate extent for the Irriga-tion of their Gardens.--

The head works of the Ganges Canal therefore were in limine, determined by the Priests and the people, so far as supply was concerned, it was only a matter of choice. The source from whence ~~[illegible]~~ their ~~supply~~ was so ample for the purposes of a Canal, and the only questions ~~[illegible]~~ left for my consideration, were those of capabilities; ~~these~~ depend-ed entirely on a true survey, or lines of longitudinal and cross sections, the former from the de-parture of the canal (to which I have alluded as the source, carrying the supply) from Hurdwar to a point south of Kunkhul, and the latter ~~[illegible]~~ an accurate profile of the ground through which the Canal would pass. The high water marks of floods, the effects that these floods had upon the islands, and the capacity of the different channels, especially that one which passed under the town of Hurdwar and Kunkhul had also to be ascertained. A series of levels on the above plan, in con-nection with a survey shewing the full details of channels and Islands, disentangled the whole question from any difficulties, and at the same time unmistakeably determined the point from whence the head of the Canal was to leave the branch.--

There was a well trodden foot path down a Ravine leading to the waters edge in the branch running from Hurdwar to Kunkhul. At the head of this Ravine and overhanging the River was a

large

(Ficus religiosa)
large pepul tree, and at its root a lingam. The spot itself went by the name of the Guntis Ghat, but there was neither building nor temple, no flight of steps, to shew that the ~~spot~~ spot in question was remarkable for its sanctity. The ~~spot in~~ spot in question was situated on the down stream side of two mountain torrents of no great dimensions, but of sufficient consideration to render their inlet into the canal channel a matter of inconvenience. The section of the branch at the spot in question was well defined, the sides were steep and the island on which its left side rested, was one that was raised above the ~~levels~~ of inundation, and consequently well adapted to my purposes. The spot ~~in question~~ was situated on the lands of the Myapoor estate.

This Guntis Ghat, therefore, was determined upon as the point at which the Head works should be erected, and from whence the canal excavation should commence ~~its course~~.

For the details of the examination of the bed of the Ganges and the branch which had now become a leading feature in the project, the Atlas which accompanies this volume must be consulted. My levels, however, were carried from a point North of Kunkul to the junction of the branch with the main River which as I have before noted takes place at about 2¼ miles ~~North of~~ south of Hurdwar. The total declivity of surface on this line was 34.10.4 in a distance of 19864 feet the branch itself was well adapted

to

to the purposes for which it was required, its average width was 300 feet and its section at those points where it was free from branches was deep and well de-fined. Immediately above Hurdwar however, the branch is connected on its right with a good deal of drainage running from the Hills and flats situated in the Dhyra Valley, but inconvenient as this might be, it presented no obsta-cles to the passage of the Canal supply. At a point on the South and immediately below the Town, a second tributary, which is designated the Puttā Rao, enters the branch on the right. This Puttā Rao is a mountain torrent of no great magnitude but runs on an extraordina-rily steep slope, and comes into connection with the Branch at a point almost immediately after it has left the mountains, it will in all probability be the cause of annoyance in the quantity of Silt with which its waters during floods are loaded. its position is, however, above the Masonry works at the Canal Head, and I anticipate that the evils which might arise from the silt [illegible] brought down by this Torrent will be very much modified by the stream which will hereafter pass down the branch, and at all events that whatever the amount of silt may be, its occurrence at intervals and during the rainy months, will lead to little or no interruption to the use of the Channel. I look upon the silt that will be here deposited much

in

in the same light as I do that
~~on the~~ Eastern ~~Kinnama sand bar~~
which, after each flood in the
Muskuna, is deposited on the
upstream side of the Regulator
at Kulsea and between that
point and the Dam; ~~[illegible]~~
is so infinitesimally small as
compared with the area of the
Canal bed below the regulator,
that its admission ~~into the Canal~~
is a matter of no importance and
of no consideration whatever. At
the time ~~that~~ I visited the branch
in 1839 ~~at the point where it leaves~~
~~the parent stream~~ the volume
of water passing down its course
was equal to 2500 cubic feet per
second; ~~with~~ strong rapids at its
mouth in themselves ~~offering~~
facilities for admitting a further
supply. Immediately north
of Hindawan a great portion of
this water escaped through a
wide and extended channel that
passed off to the Main Stream,
and opposite the Great Ghat at
the Town itself, a further escape
was effected by a similar chan-
-nel. There was a smaller ~~escape~~
channel situated further down
the branch, which was only ef-
-fective as a line of escape during
heavy floods: it was proposed
to ~~apply the~~ temporary bunds or
embankments across the heads
of these escape channels, and
by advancing a spur into the
River at the head of the branch,
to obtain from the main stream whatever ~~supply~~ was
necessary. These were my views
in 1839-1840 when designing
the original works, and they
have been carried out very
closely

closing or as nearly as the changes that have taken place in the bed of the River would admit of; [illegible] feet are [illegible] [illegible], and in the year 1833 they are [illegible] to [illegible] [illegible] of water in the [illegible] and [illegible] [illegible] [illegible] + [illegible] opposite [illegible] + [illegible] at the [illegible] [illegible] the [illegible] of the River and [illegible] [illegible] and Islands [illegible] the same as when I [illegible] visited them in 1834.

During the year 1835 [illegible] ~~[illegible]~~ [illegible] measures were adopted ~~in preparation~~ for [illegible] [illegible] [illegible] down in [illegible]. These measures consisted in throwing strong bunds or embankments over the courses of numerous channels that brought down during floods unnecessary supplies of water ~~[illegible]~~ ~~[illegible]~~ they did their duty [illegible] [illegible], ~~[illegible]~~ ~~[illegible]~~ the excavations without any material interruption ~~during their progress~~. The ~~[illegible]~~ channel which is entirely [illegible] through beds of shingle ~~[illegible]~~ ~~of a [illegible]~~ 14750 feet long, with a slope of bed equal to [illegible] feet [illegible] the initial depth of digging ~~at the head of the [illegible]~~ was 3'. 10" and the depth is ~~[illegible]~~ uniform [illegible] ~~[illegible]~~ the point established at [illegible] for the proposed Regulating Bridge at the [illegible] Ghat. It was ~~[illegible]~~ when laying out the line of

excavation

excavation which runs directly in front of the Ghat or main Ghat, and the other Ghats and buildings of the Town of Brindaban to keep the main channel and the deep excavations as far as possible to the opposite side of the river in a manner which appears to me to be desirable both for the purpose of preserving the foundations from injury, and for maintaining the water ~~[illegible]~~ of a depth in the immediate neighbourhood of the Ghats which are in general use by the bathers. At the present the water is generally shallow but in many places below the town, the ~~[illegible]~~ is so deep as to be not only impassable but actually dangerous for those who frequent them ~~[illegible]~~; at these Ghats the narrow space between the water and the buildings is a bar to the ablutions & bathing places for crowds of people. It was proposed therefore to make use of the shingle taken from the excavation in filling in these deep and dangerous holes at the foot of the Ghats, and to restrict the depth of water along the whole face of the buildings of the town to 1½ or 2½ feet. This narrow strip of shallow water stretching along the whole face of the buildings both above and below the Ghat or main Ghat, would during the annual fairs offer facilities for bathers and others which do not at present exist, the deep pools which now render bathing dangerous would be removed,

and

and independently of the ad-vantages thereby gained to the community, additional security would be given to the building. To those who are acquainted with Hurdwar at the period that I am alluding to, I need hardly observe that the Pilgrim in his ablutions at the [illegible] is prevented from going to the right or left by the uncertain depths of the water, he must either retrace his steps up the road, or cross the branch. The plan which has now been carried out might be still further improved by establishing a barrier, an Iron railing for instance, at a distance of 15 [illegible] from and parallel to the Ghats, so as to prevent all possibility of accidents from the [illegible] going into the deep and rapid part of the Channel. The main current will necessarily be on the opposite side of the branch, and the bathing places will be restricted to comparatively still water. Under this plan, in fact, although neither the sanctity nor exclusiveness of the [illegible] will be interfered with in the smallest degree, the con-course of bathers will not after their ablutions are completed, be necessitated either to force their way back again up the road, or to cross the River, but every facility will be offered for their escaping to the right or left and reaching the town through the numerous roads and passages which connect the main street with the River face. The means of ingress and egress might be much improved

by

by the local authorities of the District, the passages down to the water side might be maintained open, and free from impediment in the shape of huts, shops temporarily projected from the walls; and the heaps of rubbish which are allowed to accumulate in native Towns; wide roads or ramps might also be constructed both on the Northern and Southern extremities of the Ghats; and as a still further improvement Bridges of Boats might be established across the stream, so as to connect the Ghats with the opposite island, and keep up a free communication which would be especially convenient at the time of the annual fair.

At the [illegible] that the works which are immediately connected with regulating the Canal supply, and delivering it into the main Channel, have been constructed with due attention to economy; they consist of a Bridge with ten bays or openings across the mouth of the Canal with shutters, each bay being 20 feet in width; a line of Revetment connects this bridge with a Dam which is built across the branch, and ~~which~~ ~~is~~ furnished with sluices in its centre and overfalls on its sides for the purpose of passing off floods: the design is precisely the same as, only on a larger scale, ~~[illegible]~~ than the Head works of the Jumna Canals, the principle being to maintain the supply which is brought down from the main

River

River in a Reservoir ~~which is open to a~~ subject to regulation by a Dam, the water sufficient for the Canal supply passing down the Canal Channel through the Regulating Bridge, whilst that which is superfluous is allowed to escape through the Dam Sluices. During the rainy months and when the supply in this Reservoir exceeds that which is required, or at periods when a necessity occurs either for laying the Canal dry, or for reducing its supply, the purposes of the works are inverted, the Regulating Bridge being either partially or perfectly closed and the Dam Sluices being correspondingly opened, the Dam in that case becoming the discharge and waste escape for the water. – A full detail of the construction of these works will be given in its proper place, the works themselves, however, are figured in Plate XIV of the Atlas. – On the right and up-stream flank of the Regulating bridge, an arched passage for the admission of the Buchna Nulla, one of the mountain torrents that I have before alluded to is pierced through a line of Revetment which extends upwards and is terminated by a ~~line of~~ Ghat or steps resting on a Sweep of Revetment, ~~which in-cludes~~ an old native building ~~to which it affords~~ protection. The expense of these Revetments and Ghats became a heavy item in the ~~Estimate~~, the pro-tection

-lection, however, which they pro-
-vided against the inroads of
the stream, and the admirable
security which they offered both
to the Inlet of the Bochna nulla,
and to the native buildings
which they were designed to pro-
-tect, rendered their construction
an useful appendage to the works
The Ghats moreover, as offering
accommodation to Pilgrims
and others who visit Hurdwar
and its sacred precincts, may be
received by the Hindoo as some
atonement for the liberties taken
with the Ganges, as well as with
the tutelary deity of the great
upon the site of which these
works were constructed. The
Hurkee Pairee Ghat of the original
survey has now been converted
into an extended line of stone
steps washed by a running
stream, and provided with con-
-venient approaches for the ac-
-commodation of the bathing
community. Near the site of
these works is a house built
for ~~[illegible]~~ and other ac-
-commodation for stores and
necessaries required for the use of
the works. The Regulating bridge
over the Canal, and a bridge
which is built over the Bochna
nulla, afford the means of cross
communication between the
Towns of Hurdwar and Kunkul,
this being further facilitated
by the opening out of wide
and efficient approaches to the
Towns themselves.

The depth of Excavation at
the.

the point where the Canal Chan-
-nel commenced and upon
which the Regulating Bridge
was situated was 92'83 feet,
the upper 17 feet consisting of
firm clay which rested upon
a stratum of shingle: the ma-
terial derived from this exca-
-vation was used in forming
an extended platform between
the Bridge and the right flank
of the Dam; and the shingle,
at least that portion of it which
was in sufficiently large boulders
to render it serviceable, was
used largely both in the found-
-ations and in the superstructure
of the works; at a date posterior
to the completion of the Regulating
Bridge, a great quantity of the
boulders was carried away to
the different works which were
situated in the neighborhood
of Goowalapoor and Bahadoorabad;
~~[illegible]~~ and the esplanades
in the neighborhood of the
Dam and Regulator were then relieved
from ~~a great quantity of~~ material
which useful as it was elsewhere,
was a disfigurement in its
original position, where it was
deposited in mounds occupying
~~a considerable space in a [illegible]~~
which would have been much
improved by being perfectly level.
At the period however when
the water was admitted into
the Canal, and when the works
at this point were completed,
the esplanades in the neighbor-
-hood had been ~~relieved of the~~ cleared of all
extraneous earth and shingle,
and

and the difficulty of disposing of so much excavated matter, which in the first instance really appeared to be insurmountable was by the good management of the Executive Officer completely overcome.—

From the Regulating Basin the canal Channel leaves the bed of the Tamaes; at this point therefore the work assumes an entirely new interest, and as I write these Chapters for the information and instruction of the Juniors in the Canal Department, and for the benefit of those who may be hereafter called upon to design and to execute works of a similar nature, I shall not hesitate at the expense of being thought by the general reader somewhat tedious, to enter into a full detail of the progress, and of the deviations from the original project, which time and a better acquaintance with the nature of the mountain torrents that we had to deal with, rendered necessary.—

~~[illegible]~~ to accompany the text with the calculations upon which the excavation and works were based, and which were given in appendix to my Report of 1845; they will however be interesting to refer to, when the designs of the completed works are fully comprehended, and as ~~these calculations~~ they are in fact the basis upon which the whole structure

was

has been raised, not only as re-
-gards the Canal as a [illegible]
machine the faults of which
ought not to be subject to
disarrangement, but as the
means of performing a certain
amount of Irrigating duty
the returns from which ought
not to be liable to disappointment
the Appendix in Question has
been transferred to the volume
of Tables, ~~[illegible]~~

From the [illegible]

[illegible]

Diag. IIa

[illegible]

be

be understood [illegible] as those
upon which the works were de-
signed, and which in the
interests of the [illegible] by
Regulator [illegible] to the
head works [illegible] was
originally projected.

With these remarks as in-
troductory to a proper understand-
ing of the project & line of
operations from the Regulating
Bridge downwards, I now come
to the detail of the Channel
from the bridge above mention-
to the spot where it is crossed by
the [illegible] Trunk Road, to within
a short distance of which the
[illegible]
as [illegible] canal
on the [illegible] ~~[illegible]~~
the course [illegible] parallel to, and
within [illegible] a low spur
of hills which [illegible] out in
the direction, it [illegible] the spur
by a gentle curve to the west
passing the Town [illegible]
on the left, and proceeding in a
direction close to [illegible] ~~[illegible]~~ east
of the Town [illegible]
the neighbourhood of the [illegible]
drainage at a distance of [illegible]
Miles from the Regulator. [illegible]
[illegible]
[illegible] extended [illegible] the hills
towards the [illegible], and it was
necessary to [illegible]
[illegible] as well as other
intervening depressions to the
[illegible] Channel. [illegible]
three [illegible] one in
[illegible], two [illegible] were
derived from the two spurs of
hills along the foot of [illegible] the

[illegible]

land was inundated, and the third was connected with the [illegible] the town of [illegible]. It was projected in the original project to adopt [illegible] to the [illegible] [illegible], which was the [illegible] to give an [illegible] to the natural [illegible] drainage, and allow the floods from these comparative [illegible] to expand them [illegible] in the Canal channel; and to [illegible] the [illegible] [illegible] by taking advantage of the [illegible] of the country, and turning it off to the [illegible] valley, by which it was [illegible] that [illegible] relief would be obtained. –

The [illegible] but it was [illegible] only as [illegible] the flood water during [illegible], but to act as a supply feeder [illegible] the purposes of the [illegible] [illegible], and as the fall from [illegible] of the Canal [illegible] the [illegible] [illegible] was about a third was considerable, it was proposed to build a [illegible] mills [illegible] the [illegible], and to maintain this [illegible] as a supply [illegible] ~~[illegible]~~

The [illegible] drainage was [illegible] through which the canal excavations were [illegible]. It was however of less importance than the former one. – At [illegible] there were no [illegible] drainage at all, the flood water appears to have [illegible] over the country

and

and it was very evident from their experience [illegible] the canal embankments that it was to their vigorous being in active hostility; in the early stages, this hostility was exhibited in breaking through the embankments and cutting its way into the canal by the formation of a new channel; subsequently, however, the floods started to pass into the drainage at the site of a bridge that was near opposite the town of [illegible] [illegible], and [illegible] swept away a long tract besides doing further injury to the structure; these and other fractures had up to this time been excavated for the purpose of conveying the water to the [illegible], but as they did not answer their intended purpose, and as other views with reference to the drainage were then contemplated, I determined on making an Inlet opposite the town of Jwalapur, for the purpose of conveying the drainage water from that [illegible] country. —

The experience that had been gained by the intimate observation of a number of years, of the drainage and of the boundaries between the canal and the lines of natural drainage, had at this point thrown an entirely new light upon the method with which they also ought to be treated. The Canal Channel which as I have before stated was

excavated

extended to a point near the Camprur [illegible], have for years ~~[illegible] in the [illegible]~~ [illegible], the whole [illegible] woods from the above line, without further means of [illegible]. An opinion which had [illegible] in the [illegible] [illegible] [illegible] [illegible]; this opinion [illegible] [illegible] [illegible] raised [illegible] [illegible] [illegible] floods and [illegible] [illegible] that would [illegible] [illegible] that the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] drainage [illegible] [illegible] [illegible] [illegible] [illegible] area of [illegible] [illegible] [illegible] which [illegible] [illegible] completely [illegible].

[illegible] [illegible] [illegible] [illegible] from these sources appears to [illegible] [illegible] consequence.

[illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] through which [illegible] [illegible] [illegible] pass, it was [illegible] [illegible] to build [illegible] [illegible] [illegible] [illegible], each [illegible] [illegible] 20 feet [illegible] [illegible], the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that which was built [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] sufficient [illegible] [illegible] the maximum [illegible] water in the Canal, and [illegible] [illegible] on the [illegible] to admit of the passage of the highest [illegible] floods.

[illegible] Creagh [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the point, situated [illegible] [illegible] the Town [illegible], this [illegible] will provide [illegible] for Irrigation for the village [illegible] [illegible] and [illegible] [illegible] on the right bank of the [illegible], and will

give

give a supply to [illegible] [illegible] lower [illegible] it is proposed to establish in the vicinity of the town of Kunhil. By this ~~means~~ the necessity for [illegible] on the upper reach [illegible] [illegible] in the [illegible] [illegible] [illegible] [illegible] [illegible] with [illegible] [illegible], and the [illegible] of having the channel through [illegible] [illegible] [illegible] [illegible] [illegible] through the upper part of the town as [illegible] [illegible] water comes down [illegible] get clear of floods [illegible] [illegible] [illegible] dangerous supplies of water will be entirely removed. It is evident in part that the proximity of a town is not at this [illegible] to [illegible] and [illegible] without discharges of water [illegible] [illegible] [illegible] from its, ~~[illegible]~~. From the [illegible] [illegible] now made it will [illegible], as a [illegible] [illegible] at all, and I have no doubt that in a few years, all vestiges of its existence will be gone.

Between the [illegible] regulating Bridges and the [illegible] Bridge, the following works have been constructed.

4 Bridges for communication [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

1 Outlet [illegible] [illegible] [illegible] Kunhil.

3 [illegible] on the right bank | [illegible] Kunhil [illegible]

The excavation on this line is completed with the exception of that portion near the Kunhil drainage crossing and which was ~~only~~ 996 feet in length with an average

average depth of digging of 8 feet only, but very [illegible] in 8 miles [illegible] it amounted to 9 feet, whilst in places 12 & 14 feet, the maximum depth being 25.05 feet from the surface, throughout the whole [illegible] the soil was sand with a large admixture of clay, and at [illegible] was [illegible] sand from [illegible] to the [illegible] bridge the canal bed was excavated in Shingle.

The left bank has been formed into a wide and spacious roadway which is continued from the [illegible] Regulating Bridge to the 1st Class [illegible] at the [illegible] Iron Works; this road is also a [illegible] for the canal Establishment, and is in fact a good carriage road for every purpose that could be required. The right bank as well [illegible] from the [illegible] of [illegible] which has been described, is [illegible] at [illegible] different points, and it has not been considered worth while to [illegible] the [illegible] of commu-nication by [illegible] approaches over these [illegible], or to [illegible] any [illegible] for [illegible] and maintaining a [illegible] passage along the bank [illegible] the [illegible] will be provided [illegible] the [illegible] It is supposed that the scale upon which the works have been made for the admission of river water which ~~has been determined by the experience~~ of 12 years of observation, will place the banks on the right of the canal out of all jeopardy. —

The changes that have taken place

place in the distribution of works on that portion of the Canal between the Mayapur Regulating Bridge and the [illegible] Cut, [illegible] it will be observed that increased inlet to drainage water on the right, and to [illegible] outlet on the left. The causes for such changes have been described, as arising from the increased quantity of flood water in the Rutmoo Torrent and other lines being greater than it was originally estimated, and from a desire to relieve [illegible] which the Canal is involved, by introducing into its precincts an element of danger, as an open channel subject to sudden and impetuous discharges of flood water. The additional inlet to the Jowalapoor drainage was proved by ultimate and various experience to be absolutely necessary for the convenience of the Canal; there were other reasons which will be hereafter explained, for the relief of the country at this point, and by the method adopted was considered to be expedient.

From the point of the Canal where the regulating bridge is intended, or [illegible] situated immediately above the Dhunjpoor Torrent, the line upon which the Canal channel has been excavated and the works [illegible] is one of very peculiar interest. It is that upon which the works have been subject to the greatest change from the original design, and it is one where the circumstances under which the Canal channel is brought in contact with torrents

deserves

deserves the marked attention of all those who are interested in the work of Engineering under difficulties.

To enable us to place the details with any degree of perspicuity before the reader, it will be necessary to bring under review the whole of the country lying between the Ranipur and Puthri torrents, including the drainage which gives rise to these torrents; to explain the project for passing the Canal through this line of country, as designed in my report of [illegible], and to show the nature of the changes that have been made in that project ~~in the actual work~~ ~~which have been actually~~ [illegible]. The total length of main channel which will be made in this division is equal to 8 miles.

By reference to plate III. of the Atlas which exhibits in the fullest detail the surface features of the country, and which is in fact a contour of the whole of the land lying between the mountains and the canal, a good general idea of the circumstances under which the works were placed will be obtained. It is desirable that these general features of the country should be understood before the details of the canal operations are considered, as the ~~[illegible]~~ [illegible] difficulties ~~attending upon~~ ~~as then met in~~ the country passed by this line of the Eastern Jumna Canal, amongst which may be noted the very remarkable one of Double [illegible] which may, in all probability, be taken advantage of

of with great benefit to the ~~Ganges Canal~~ works. — In the present instance the slope in question proceeds from east to west, instead of from west to east as it does in the drainage on the western water-shed with which the Eastern Jumna Canal works are connected: in other cases it has afforded the means of projecting a line of canal on slopes sufficient for the purposes required, and in other cases, it has placed in our hands the ability of regulating the distribution of the flood water, I have in a former Chapter explained how beneficially this natural arrangement of slope combined with topographical advantages, from which I am sorry to say the Ganges Canal works are utterly precluded, has been made to bear upon the works of the Eastern Jumna Canal in relieving its works from the effects of mountain streams, and although there is no probability of freeing the Ganges Canal works altogether from flood water, in the way that the mischief on the Eastern Jumna Canal has been [illegible], by escapes into Rivers which are entirely unconnected with the works; we hold in our possession the means as I before said of regulating its distribution, and as I have in some degree made use of the means thus placed in our power, it may be as well to lay some stress upon them here preparatory to the detail which will ~~hereafter~~ follow.

The remarkable points in the Country which I am about to describe, as connected with the Canal

Canal works, were, 1st the extraordinary slope upon which the mountain streams (which crossed the line at right angles to its course) passed onwards to the lower [illegible] of the Khadir; 2nd the peculiar circumstances under which the beds of these streams exhibited themselves, or more properly speaking, did not in some cases exhibit themselves at all; and 3rd the alluvial nature of the soil, with a disposition of spring water which as leading to complete drought in one and complete saturation in another part of the line, was particularly inconvenient.—

The line of Canal in proceeding across the Ranipoor torrent onwards to the Rutmoo, gains in departure from the Hills considerably; at the point where it crosses the former River the Hills are at a distance of 2 3/4 miles, halfway on its course, or at the point where it crosses the Puthree it is 5 1/2 miles distant, and at the Rutmoo the distance has increased to 10 miles: this is a question of some importance [illegible] estimating the value of the flood water.—

It was proposed in my project of [illegible] to adopt the Dam system, as practised on the Jumna Canals for all the streams the courses of which were intersected by the Canal channel; to confine the masonry works to Culverts only; to dispose of the superabundant fall by crowning by masonry descents, and to reach the Rutmoo

Dam

Dam by a gentle sweep, from the termination of which the leading on Roorkee would be in one uninterrupted line. —

The Country to be crossed may be thus described. The Ranipore Stream, which is the most defined line of drainage west of Sowalupoor, is directly connected with the mountains; its catchment basin may be estimated sufficiently accurately for our purpose at 45 square miles. From its debouche from the mountains to the point of intersection with the canal, the distance by a direct line is 2 3/4 miles, which by the tortuous course on which the flood water runs may be increased to [illegible] miles. The total declivity of bed on this line is equal to [illegible] feet per mile. [illegible] original survey of 1839/40 showed that at a point 1800 feet above that where the canal intersects the line of the Ranipore Stream the water spreads over the surface of the country, leaving no trace of ~~[illegible]~~; the average breadth of the bed of the torrent was at that line 100 feet, and borings which were carried on in the bed at the point where the canal works were to be constructed showed at 3 different places that there was favorable soil at a depth of [illegible] feet from the surface; the boring, however, showed one sign of [illegible] water at a depth of [illegible] feet; at [illegible] a [illegible] to the west and immediately on the edge of the high bank skirting the torrent, the ~~surface~~

in

of the water in the river [illegible] was [illegible] the Earth's surface. The deposit in the bed was fine sand, in the depth above [illegible], and the [illegible] [illegible] and [illegible], sparingly with [illegible] [illegible]; but by the extreme depth ~~that~~ the river ~~[illegible]~~ the soil produced was mostly sand more or less mixed with clay. Immediately at the point where the canal and torrent come in contact; the latter had within the last few years deserted its direct course towards the village of Dhunae and had made an abrupt turn to the westward, in the bearing in fact upon which the Canal was to be carried. This abrupt turn had occasioned a [illegible] channel [illegible] under the [illegible] bank, the position of which at that period was one of [illegible]; the effect of a sudden turn to the south had become the direction upon the [illegible] lands of Boungla ~~[illegible]~~ the flood waters [illegible] itself, leaving as is usual in such cases, [illegible] deposits of sand. The site of the works was therefore at the head of a delta, the eastern branch of which ran in prolongation of the [illegible] on the approach to the works and [illegible] of the village and lands of Dhunae; the western turned off abruptly to the Boungla lands. The position determined upon for the dam was on the old or easterly branch, which it appeared from

from the Ganges Canal in 1855 [illegible] (as is proved by the data [illegible] my examination of the works) was then in existence at that period.

When, as we noted, that the slope [illegible] resulting from the debouching of the Canal from the Weir to the point of intersection of the Canal channel 18 in 19 or 18 [illegible] feet [illegible] above the intersection, or a distance of 2½ miles the slope was 1.6 feet, or 16 feet per mile. The effective slope in that in immediate contact with the [illegible] of Canal as shown by Fig. 1 in the accompanying Sections, was equal to 15½ feet per mile; the height of the length upon which the section was taken being above, and two thirds below the line of works.

The sill or flooring of the Dam in this project was 12.25 feet below the surface of the bed of the Torrent. The work was designed without [illegible] of any description, and the outlet or Dam on the left bank of the Canal ~~admitted~~ a discharge over the [illegible] of 131½ feet in width, the series of openings being [illegible] in number and each of them ten feet wide. I have before explained that on the project of 18[illegible], the works of which I am now describing, the slope of the Canal bed throughout the Khadir was 18 inches per mile; it will therefore be understood that the different points of fixed level for the sills of Dams are deter-
-mined

main on this particular [illegible], the intermediate or descents & falls for traversing [illegible] of [illegible] being duly considered.

The advocates of the [illegible] [illegible], the upper all cultivating [illegible] to the [illegible] of the Patta [illegible] was [illegible] drainage [illegible], [illegible] into two separate [illegible], as the levels of the [illegible] upon which the canal would be excavated, might prove to be most convenient. These [illegible] were [illegible] [illegible] provision was made in [illegible] plans and estimates.

The Patta [illegible] ~~[illegible]~~ may pro- perly be brought under two [illegible] heads, viz. that portion of it which was connected with the mountains, and which may be called the "Patta [illegible]" and a tract of country lying to the eastward in the neighbourhood of the Town of [illegible], which [illegible] about [illegible] and [illegible] [illegible] distinct although [illegible] watered, consisting of grass and jungle and extended towards the mountains, ~~with~~ but the ~~drainage~~ from ~~[illegible]~~ which [illegible] very high floods, it was totally un- ~~[illegible]~~ [illegible]. The material dif- ference that existed between this ~~[illegible]~~ jungle drainage and that of the Patta [illegible] was that its flood water was entirely free from sand

sand and silt, its course was marked by deep ravines and a well defined section left to the North and westward of the town of Ranipoor; at a point about half a mile South of the Town no traces of this drainage were to be seen ~~visible~~, the surface of the country was under cultivation and there were no outward and visible signs by which a person who had not made his examination ~~of this part of the country~~ to the line of the Canal above would have formed an idea of the nature of the drainage over which he was passing. At this point the project Author, gave a design for works similar but on smaller dimensions to those at the Ranipoor Torrent, the water being admitted through the right embankment by an Ordinary left for the purpose and a masonry outlet waterway being constructed on the left for ~~the purpose of~~ passing the flood water out of the Canal.

The Puttree Rao which, like the Ranipoor Torrent, is connected directly with the Mountains, was marked at the point where the Canal intersected its course by sheets of sand, elevated rather than depressed below the surface of the country and with no signs of excavated channel; the channel in fact appeared to cease at about a mile above the point where the Canal ~~channel~~ had to cross it, and at this

point

point of cessation the sand was thrown over the surrounding country in the same fan like expanse, that had shewn itself to me at Boungfuar [illegible] which [illegible] the [illegible] of the Ranipoor drainage. — The catchment basin of the Puttu valley may be estimated at 80 square miles: from its debouche from the hills to the line of canal the distance in a direct line is 5 miles, its course, however, is an exceedingly tortuous one, its main branch leaves the hills considerably to the Eastward, and after skirting the foot of the moun-tains, and gathering in its passage the drainage of the different valleys with which it comes in contact, it takes a direction almost due South, and with the exception of a few twists characteristic of this species of river, passes the line of canal on a tolerably direct bearing; the delta or section which marks the earlier part of its course losing itself as I have before described over the surface of the country. On this tortuous course the distance between the points above men-tioned may be estimated at 6½ miles, the greater part of the country over which it passes being Forest and uncultivated lands. The total declivity of bed from the hills to the point of canal intersection was 170.65 or 27.625 feet per mile. From this point to a distance of 11500 feet South where there are marks

marks of the [illegible] [illegible]
[illegible] a [illegible]
[illegible] the [illegible] [illegible]
25 [illegible] per [illegible]. The [illegible]
[illegible] in immediate contact
with [illegible]
[illegible]
equal [illegible];
third [illegible] the
section was [illegible] above
and [illegible]
being below the line of [illegible]
[illegible] the [illegible] of the
[illegible] project was [illegible]
feet below the [illegible] of the [illegible]
of the [illegible], and the [illegible]
[illegible]
[illegible]
[illegible] on the same design
as those at the [illegible]
[illegible] means [illegible] dis-
posing of the [illegible] water of the
Putter valley, [illegible]
[illegible]
[illegible]
was projected close upon and
under the ridge upon which
the [illegible] is situated, this
ridge being the westerly watershed
of the ~~valley which constitutes~~
~~the~~ Putter ~~drainage~~.
The valley of the Putter there-
fore was under the project [illegible]
[illegible] on the left bank
with [illegible]
that on the east passing [illegible] the
[illegible] drainage, [illegible] on the
west [illegible]
from the highlands near [illegible],
and a main central line pro-
vided for the especial purpose
of the Putter [illegible] itself; the
total

Plate III.

Sections on the Rampoor, Puttri & Rutmoo Rivers

Shewing the declivity of Bed as connected with the

GANGES CANAL WORKS

Fig. 1.

Rampoor River

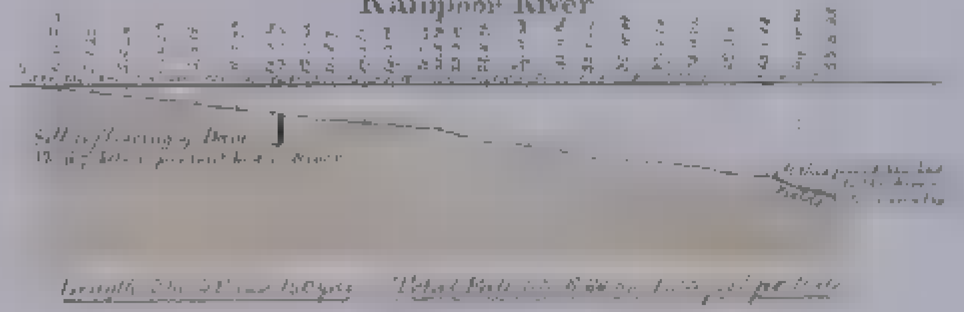


Fig. 2.

Puttri River

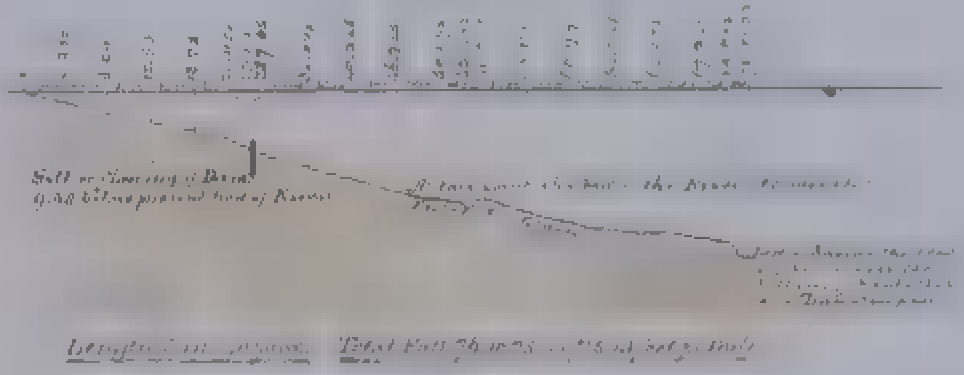
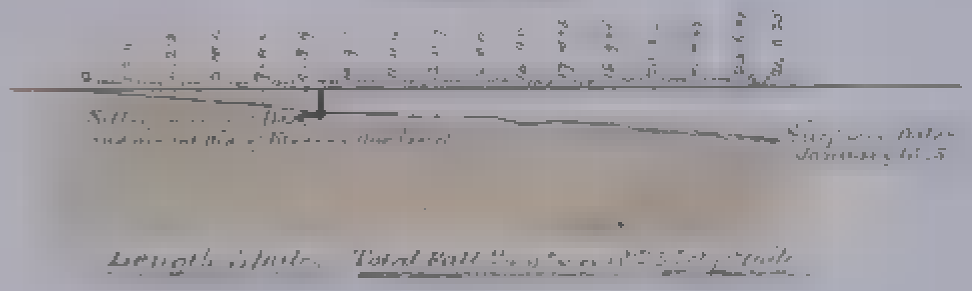
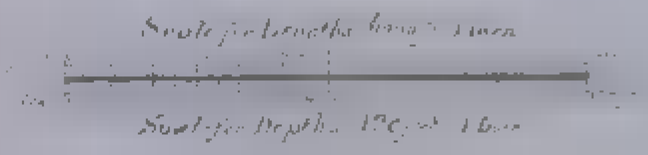


Fig. 3

Rutmoo River





total width of waterway that these 3 Escapes afforded was 140 feet between the piers of the Dams with a flush passage over their pier heads of 1½ feet. Openings of equal dimensions were left on the right for the admission of flood water.

On leaving the Puttri valley and after crossing the ridge on which the Town [illegible] and village of Tamrians were situated, at which point it was proposed to build a bridge for cross communication, the line of Canal as I am [illegible] noted, on a [illegible] of 18 inches per mile, comes into contact with the Bansnah [illegible] nulla, a [illegible] in which there was a perennial stream of water tributary to the Puttri, [illegible] the head of this nulla was situated at a distance of 1 mile from the Canal, and the [illegible] of spring water afforded a fair indication of the state of the springs in its neighbourhood; the Canal bed crossed this stream at an elevation of 5 feet above the waters surface. There were no works estimated for on this drainage, the question of inlet or outlet being left an open one.

From this point the Canal Channel was ~~proposed~~ to be carried on a gentle sweep upon the line of the Puttree River, the levels required it reached by descents of masonry equal in extent and dimensions to those which were proposed at Bahadurabad

Bahavoorabad, at this point
also a navigable line was pro-
-jected round the falls for the
passage of boats and rafts.—

The Putmoo River or
Torrent it will be understood
from the foregoing description
runs to a level considerably [illegible]
[illegible] the high land on which
the Canal ~~in its approach~~ has
been carried; the valley through
which it takes its course is at
the point of contact with the
Canal about a mile in width,
bounded on the right by a steep
and precipitous bank on which
the village of [illegible]
with its Tombs and Eedgahs are
situated. The Catchment basin
of the Putmoo Torrent may be
estimated at 126 square miles
31 of which lies in and [illegible]
at the foot of the mountains.—The
valley above the Canal works re-
-ceives the whole of the drainage
from the Nahsrao and Sukrouda
Forests combined with that which
pours down from the mountains
~~into~~ the different Ravines and passes
on a length of 11 miles; its water
shed on the East is bounded by
that which falls off towards the
Putt[illegible] and on the West by the
slope which defines the drainage
upon the Soane river.— The ~~Gh-~~
-~~aut~~ debouches from the hills
of these torrents which are thus
tributary to the Putmoo vary
from 10 to 16 miles from the Canal
works: the main or western line
of drainage being the most distant
the greater portion of the Country

over

over which these tributaries take their course was at the period of my original surveys Forest and grass jungle, the few villages that existed being mere hamlets, with a field or two in their immediate neighbourhood. From the point where the main branch of the Cutmoo left the Hills to the bed of the River at the intersection of the Canal line, the slope was 626'. 11·2" or averaging 30·18 feet per mile; below the point of intersection this slope decreased, but the effective slope or that in immediate contact with the works as shown in Fig. 3 in the accompanying Section was 8·23 feet per mile, one third of the length on which the Section was taken being above, and two thirds being below the line of works.

The Sill or flooring of the Dam on the Cutmoo River, co-incided with the natural level of the bed, and the arrangements for inlet and outlet were on the same plan as those that I have before described, viz: Masonry Sluices on the left for the purpose of passing off, and an open breach through the right embankment for admitting flood water. On the right of the [illegible] ~~[illegible]~~ for carrying the water of the Bhugulee (a little stream or nulla that runs at the foot of the Peerunkulleer bank) under the Canal Channel, so that inundation which would necessarily arise where the course

of

of the stream was interrupted by the Canal embankments, might be prevented. Attention was also drawn at this time to the inundations consequent on the canal bed, and that of the River being on one level. It was observed that under this circumstance the maximum head water in the Canal which is proposed to be 10 feet from the sill of the Dam, and 14 feet from the bed of the River, must stand in back water, forming an inundation on the upper side of the Dam; by which not only would a serious disfigurement arise to the works, but the rank vegetation consequent on inundation extended over such a large surface, would in all probability affect the health of the neighbouring population, as it would inevitably provide a harbour for tigers and other vermin. The evils of a large inundated tract at this point were undeniable, and although I proposed a method for curtailing this evil, which was the least expensive that could be devised, I suggested at the time, that it was by no means improbable that during the operations in this valley other and perhaps better remedies might offer themselves. It was natural in fact to look to the system of tunnelling which had been proposed for the Bhugulea nullah, as one equally appropriate to the relief of the Rutmoo inundation.

The works proposed in my Estimate of 1845 for the Rutmoo River consisted of a Dam with 40 Sluices of 10 feet wide each,

and

and a plank sluices 10 feet in ~~width~~, The first passage over the sill heads being 10 feet above the level of the canal bed made equal to 76½ feet.

A Bridge for the purpose of regulating the canal supply and for preventing the floods of the Rutmoo from passing down the canal, was ~~proposed~~ to be constructed across the canal channel between the River and the Peera-i-ulbeen ridge; the design of this work with its arrangements for regulating the supply were similar in every respect to that at the canal head ~~a time after~~.

Having now passed over in detail the country between the Ranipoor and Rutmoo Torrents, having described the slopes of country over which the line of canal had to take its course, and having noted its relative position to the mountains; we may now advert to the different works which were proposed at this period for overcoming the difficulties which were offered by the Mountain Torrents, point out the comparative want of information that we possessed at the time in question, to that which we held at a later period. The Surveys upon which the whole design of the Ganges canal was based, were made by myself unaided by staff of any description, and were carried on at a time when my attention was divided by the responsibilities of other duties. These duties neither permitted a prolonged absence from them, nor of any interruption at all to the

daily

daily routine of office business. I was therefore necessitated to confine my views to the determination of a line for the Canal and to the examination of the Torrents in their immediate connection with it, to the details in fact which are given in extenso in the report of 1845 for which the whole of the data ~~which~~ I had at that time in my possession, and upon which the Project was formed, ~~which~~ ~~are~~ [illegible] open to the perusal of all who may take any particular interest in the subject.

The valuable information which we have since gained by the numerous and I am by no means disinclined to allow the unfortunate delays that have taken place in the prosecution of these works, has ~~[illegible]~~ shown the character of the mountain Torrents in a very different ~~[illegible]~~ light to that in which ~~was originally estimated~~ they were originally judged of: the deliberate Surveys and Contour levelling which have been carried over the whole of the country between the Hills and the line of Canal, have thrown light upon the subject of the drainage of which we were previously ignorant, and it is not too much on my part to claim some ~~consideration~~ for a design projected on limited data, and unaided by those advantages which time and experience have since afforded to us.

In recapitulating the works above described, it will be observed that the Section of the Canal Chan-

-nel

-nel was continued on the same dimensions as are shown in Dia-gram IIa. The slope of the Channel was ~~continued~~ at 18 inches per mile, with a superfluous ~~slope~~ fall of 32 feet disposed of in Masonry descents; that the cross drainage was to be effected by gaps left in the right bank for the admission of flood water, and by Masonry works with sluices adapted to escape ~~allow~~ to the left ~~bank~~ ~~essential~~. The total amount of water way which was allowed for escape under this project was equal to 1106½ feet distributed as follows:

Ranipoor Torrent 131½ feet above pruned R.
Pultri do {East 93½ do {Total
{Cent. 131½
{West 93½ do {178½

Rutmoo do 746½ do

It must also be remarked that the Canal bed came in contact with the Torrents under the following circumstances

Ranipoor Torrent bed 12'7" above the Canal bed
Pultri do 9.5' do
Rutmoo do On the same level

and that the projection of the levels of the Canal bed, and the position of the falls or descents of Masonry had been devised, not only with a view of reducing the difference of level between the Canal bed and that of the mountain Tor-rents to a minimum but re-stricting the excavation of the Channel to moderate depths, and thereby escaping the springs which showed themselves in the Country between the Pultri and the Rutmoo valleys. The Bridge between Ignibus and Bush was the only work for cross communi-

-cation

-cation that was contemplated in this line of the Canal.

An attentive perusal of the above recapitulation, with the matter that has preceded it, will, with plate No III of the Atlas before him, put the reader in a position to form his own opinion as to the value of the inductive reasoning which led to an extensive revolution in the method originally adopted for dealing with the Ranipoor and Puttri drainage. ~~and consequently~~ ~~to an extensive~~ a material change in design for the disposal of the flood water; ~~with~~ modifications to the disposition of slope in the Canal bed; and in some cases ~~a~~ an increased capacity of Channel.

The views which I entertained on the subject of the effects of the Ranipoor and Puttri Torrents upon the Channel of the Canal at the point of contact, may be best shewn by an extract taken verbatim from my report of 1845. After explaining the position of the Ranipoor masonry Dam, and other points with regard to levels, with which I have before made the reader acquainted, I state: "The "masonry work being completed (or "during the time of its progress "if labourers are to be procured in "sufficient abundance) the exca-"vation of the escape at the Dam "tail ought to be commenced; "this I propose to consist of a "Channel fifty feet wide with "its bed formed on a declivity "of 24 inches per mile, which "with reference to the actual slope "of the surface of the Country, will at

"at about 6 or 800 feet South deliver
"the escape into the low land
"draining itself into the Ganges in
"connection with the Pullie river,
"the width of channel proposed
"will be sufficient to enable the
"stream to adapt itself to its
"own wants, by clearing out a
"passage suited to the body of
"water which will be passed over
"the Dam. North of the Dam" and
to this point I would draw particular
attention "and up the course of
"the Ranipoor Rao, the bed of the
"River will be deepened so as to
"meet the level of the Canal bed
"on an inclined plane the base
"of which shall be half a mile
"I propose that the width of this
"excavation should be 60 feet. -
"It may be assumed that during
"floods, the Canal which crosses
"the River at right angles, and
"which will receive in the first
"instance all the water which
"comes down the River, will hold
"from 6 to 10 feet of water in depth,
"so that a considerable backwater
"will be present to receive the
"floods that come down the Rao,
"and the meeting of the flood
"with the Canal back water will
"in the case of the depth being
"6 or 10 feet, take place at a distance
"from the line of the Canal and
"the masonry Dam - The wear
"and tear to the bed of the Rao,
"owing to this alteration of its
"levels, will necessarily lead to
"the removal of sand and silt
"all of which will be borne for-
"wards in the direction of the Canal
"a portion of this will necessarily
pass

"pass off through the sluices of
"the Dam", but owing to the
"Canal stream meeting that of
"the Rao at right angles to its course,
"a portion will be projected into
"the Canal Channel; the Dams
"and Escapes which are situated
"lower down the line will, however,
"in some measure act as a relief
"to this inconvenience, and the clo-
"sing of the Regulating Sluices of
"the Dam on the Rutmoo river
"will in all probability act as
"the means of efficiently scour-
"-ing the Canal Channel through
"the sluices of the Dam at that
"point — it is to be understood
"that with the exception of the
"periodical floods which usually
"occur during the rainy months
"only, the beds of these Raos are
"perfectly dry! The silt, therefore,
"obtained from these sources is
"merely an occasional evil". -

The plan of the inclined plane or ramp, by which the water from the Torrent was to be admitted into the Canal Channel, was evidently a crude and imperfect one, it brought into direct contact two slopes on extreme declivities, and was in fact the introduction of an evil in somewhat of an exaggerated form of that with which experience had made us acquainted elsewhere; it will be understood however from the extract above given that the body of water and current which the Canal was supposed to deliver at right angles to that of the Rao, would project a great portion of the silt forwards in the Canal Channel out of which it would find an

exit

over from the lower escapes, whilst the remainder would pass over the Outer masonry necessary for its ~~completion~~ passage. One remedy, however, was in use, of one of great inconvenience to say the least of it, and it was one that had sufficient objections, to render any dependence upon it a matter of very questionable propriety.

On my return from England and reassuming charge of the works early in 1848, the whole question of the drainage on this line of Country, was one of the first that occupied my attention. The foundations of the Ranipoor Dam in Outer were at this time in progress, and in the month of June of that year had been completed; during the progress of these operations, and during the rains of 1848, the floods were passed round the works by ~~the Established [illegible]~~ well protected embankments and it was at this time that the enormous accumulation of sand which these ~~abutments~~ Embankments led to, became an object of prominent observation; the floods during the rains of this season had been numerous, and in the month of July one of the heaviest that had been experienced poured down the river, the protective arrangements to the masonry works, however, did their duty efficiently.

After the rains of 1848, the Ranipoor River and the drainage connected with it, were ~~be subjected~~ subjected ~~be~~ to a more detailed examination, than they had hitherto experienced

and

and in the month of February 1849, after drawing the attention of the Government to the acknowledged imperfections of the admission of the Rao water into the Canal Channel by an inclined plane excavated through the bed of a sandy river, I pointed out the only remedy that appeared to me to be available, viz. the substitution of a masonry Overfall for the inclined plane, by which the levels of the Raniprur bed would be in some measure retained on their original level. The advantages anticipated by this plan were

1st Great relief to the canal Channel from silt and gravel from the influx of a torrent running in a sandy bed under a great slope.

2nd Security to the embankments in the vicinity above.

3rd Advantage to the cross communication of the Country, by retaining the bed of the Rao or River at the higher level, by which means the Road between Hurdwar and Saharunpoor which lies immediately on the north of the Canal would be maintained passable during the year.

The actual State of the works at this particular point were on the date above noted as follows. The excavation of the Canal Channel was in progress across the bed of the Rao, a bar of earth having been left across the Channel at the point immediately above that where it came in con-

-tact

-tact with it; the flooring and foundations of the Dam were laid bare and the Escape Channel was nearly completed; the found-ations of the Inlet to which I have above alluded were in progress, and a sufficiency of material had been collected to complete the work. In a report at this period I concluded my remarks by observing that "I look confidently to seeing the "whole of these works completed "(with the exception of the Dam "the completion of which is "postponed) before the next rains; "I am anxiously desirous that "such should be the case, that "we may in these works gain "some practical experience, and "consequently useful hints for "the execution of the works on the "Puttri drainage, the site of "which is a few miles below the "Ranipoor Rao."

The design of the Inlet (plan and section of which will be found in Plate No XV of the Atlas) was a plain perpendicular drop of 10 feet, with a reservoir at the foot to receive the water; the flanks were well protected by masonry wings, which were covered on the ends resting on the Em-bankments by pitching; the sill of the Overfall was 2 feet below the level of the bed of the River, the height of the drop being designed with reference to the estimated high water mark in the Canal which agreeably to the project was 11 feet. –

The whole of these works were completed

completed before the rains of 1869 with the exception of the Piers in the centre of the Dam water way. The Escape from the Dam had been entirely cleared out on a width of 51 feet, with a slope of bed equal to 4·75 feet per mile and bunds or embankments had been thrown across the Canal channel both above and below the works, so that the torrent might be confined to its own course, and not to interfere with the Canal excavation on the right or left. Under these circumstances the works were opened, or the passage of the River.—

That the effects upon these works which I am now about to describe may be fully understood, I may observe in this place, that the slope of the Inlet was equal to 10·33 feet in a length of 1400 feet or 39·5 feet per mile — whilst that from the tail of the Inlet along the line of Escape which had been provided for it was equal to 4·75 feet per mile or 6·12 in 6800 feet, the width of the torrent might be on an average 100 feet whilst that of the Escape was 51 feet only.

After a flood which occurred on the 19th June 1869, the Canal bed at the foot of the Inlet had upon it a deposit of 3 feet of sand. Light floods ~~which increased the flooding which was somewhat severe and which~~ occurred on the 25th and 26th of the same month raised this deposit 2 feet making a total depth of sand at the foot of the Inlet equal to 5 feet; During the

month

month of August following a succession of floods still further added to this accumulation of deposit, until at the termination of the rains, neither Dam nor Inlet (with the exception of the upper portion of the flanks of the latter) were visible; they were to all intents and purposes buried, and the bed of the River had formed itself on a natural slope entirely independent of the works which we had constructed for its accommodation. A perfect detail both in plan and section, of the State of the Dam & works before and after the rains of 1867 will be found on the opposite page. The results, in the very rapid extent of deposits, were by no means anticipated; the slope upon which the Escape was designed was, it will be observed, very considerable and although the comparative width of this Escape was small and might in some degree add to the evil already existing, of the capabilities of Inlet and discharge not being in equilibrium either in slope or capacity of Channel, I considered that the nature of the Current acting upon a soil of a light & sandy description would by widening out the artificially excavated Channel, dispose in some measure at least of these difficulties; ~~and although~~ It was not overlooked that deposits would necessarily take place upon the line of Channel South of the Masonry Inlet, but it was considered that these deposits would be of a

nature

nature, that would render their periodical removal a matter of little difficulty; and that in fact when the Canal was opened and the Cross Current which it would give rise to came into action, that the interference from these deposits would be of no consequence at all. –

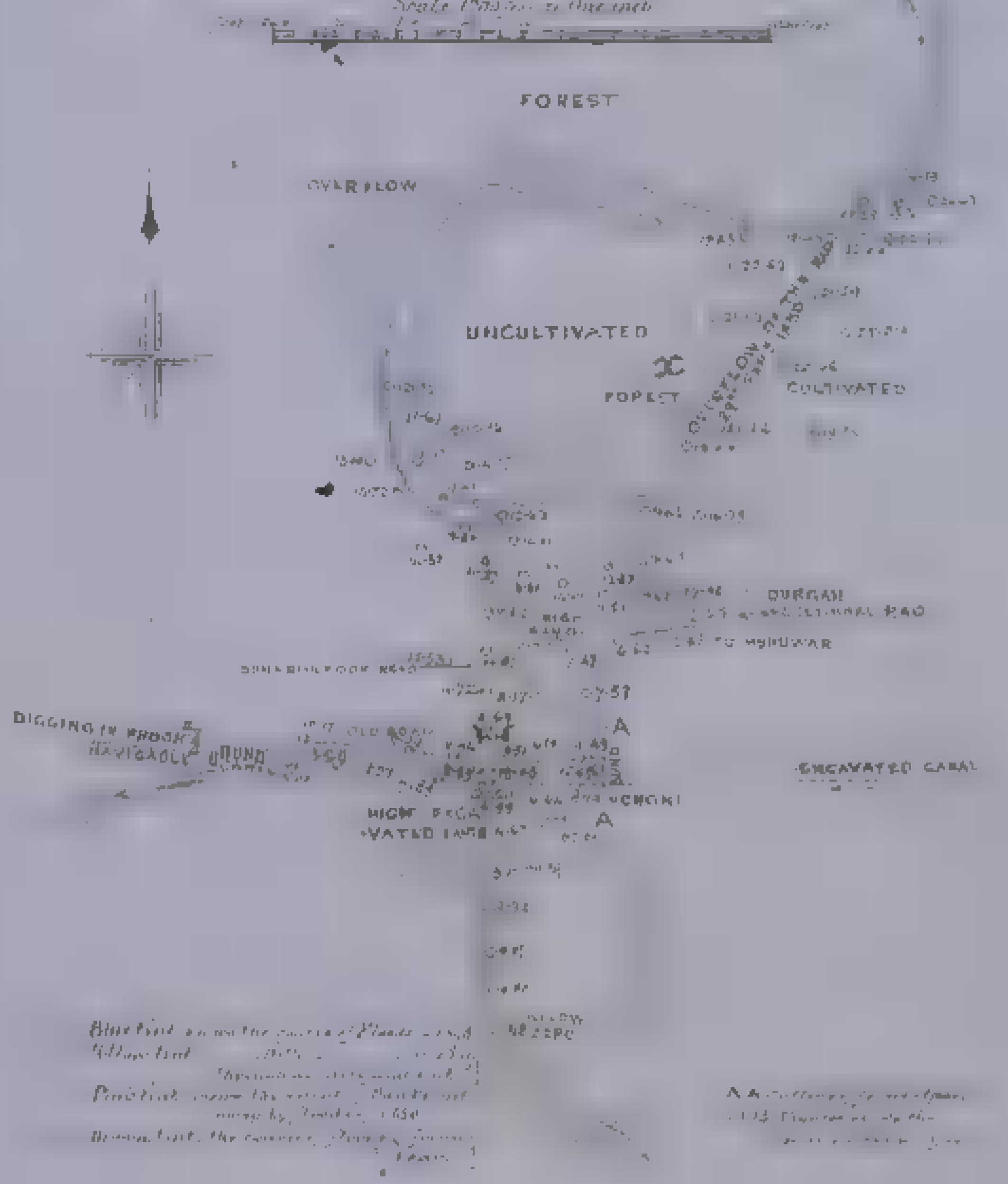
Now the effects that we above described, are by no means dissimilar to a redisposition of sand on natural slopes which occurred in the Nogong River, one of the Torrents connected with the Eastern Jumna Canal, and as the case in question is exceedingly illustrative of the changeable nature of these sandy beds, and of their disinclination to be interfered with, I shall make no apology for introducing the subject here. –

The Nogong Dam is a masonry building, constructed across the bed of the Torrent, which has a catchment basin of about 56 square miles 25 miles of which are mountain, and the remainder open forest and jungle country lying at its foot. The Dam itself is situated at a distance of [illegible] miles from the hills, and the slope of the bed of the Torrent at the point upon which the building was constructed, was 11½ feet per mile. There were 24 Sluices of 7 feet width each adapted to the centre of the Rivers course, the 6 centrical ones having their sills or flooring 2 feet, and the side ones having their sills 4 feet above the bed of the River; the piers of

these

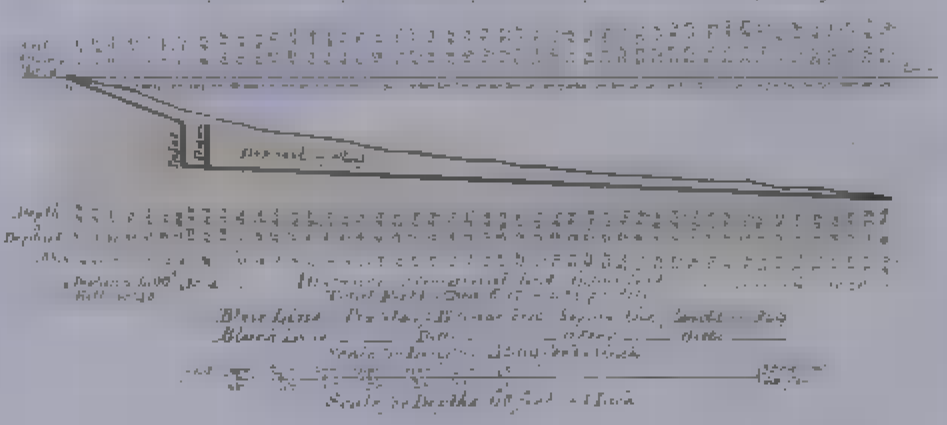
Diag. IV

Sketch of the Ranipoor Rao as connected with the Ganges Canal



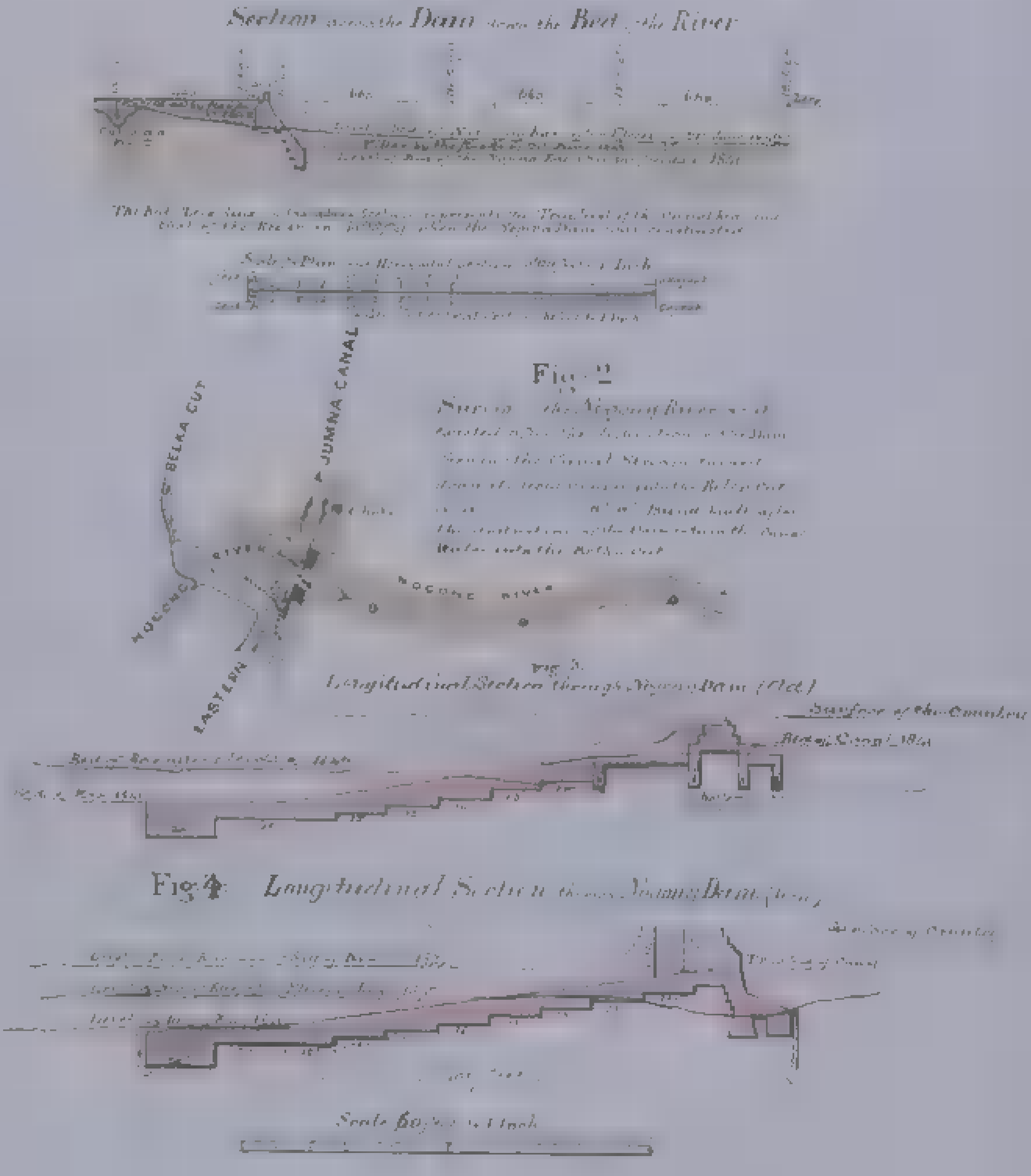
Section on the Ranipoor Escape

Shewing the levels of the bed before and after the Rains of 1849



Diag: V

Fig. 1


Section across the Dam across the Bed of the River
Fig. 2
JUMNA CANAL
BELKA CUT
RIVER
Fig. 4

these sluices were from the bed of the River up to the [illegible], and above that point the floods passed over the [illegible] [illegible] sheet of water.

At the time that this work was constructed, in 18[illegible], the bed of the River at the point where the Dam was built and [illegible] above and below it, was [illegible] [illegible] with a [illegible] of [illegible] [illegible] [illegible] Section, see Fig. [illegible] & Fig. [illegible]

From the [illegible] of 1830 to [illegible] of 18[illegible], a [illegible] succession of [illegible] [illegible] upon the [illegible] of this [illegible] took place; [illegible] [illegible] [illegible] [illegible] [illegible] a new [illegible], a new [illegible] was constructed [illegible] [illegible] and [illegible] of [illegible] [illegible] flanked [illegible] [illegible], this new [illegible] was made [illegible] a [illegible] adapted to the [illegible] that the bed of the River had at that time assumed at a [illegible] [illegible] of the [illegible] of the Dam.

At the commencement of the [illegible] of 18[illegible], that is to say [illegible] years after the Dam was constructed, the total [illegible] of the [illegible] [illegible], [illegible] all annually [illegible] [illegible] [illegible] material was [illegible] [illegible] its [illegible]; year after year [illegible] had been made, and as it was [illegible] [illegible] had been given to its stability. Early in the [illegible] of 18[illegible] [illegible] a very heavy flood came down the [illegible] River, the water in its passage over this [illegible] rapid of

of box work (the bed of the River south of the tail being at this time 21 (twenty one) feet below the sill of the Canal) undermined the piling and hurdle work on the left flank, carried away that portion of the tail in its immediate proximity, and was only checked in its career of destruction by the masonry platform, over which it fell in an uninterrupted cascade of at least 15 feet in perpendicular height. The injury was of such magnitude, and the accident had occurred at a period when a succession of floods during the three following months were certain, that there was neither time nor material available for doing any thing further than making a very inadequate repair, and the only prospect that offered of preventing irreparable injury was by passing the flood water down the Canal Channel, and if possible putting the Dam out of use for the rest of the season. It so happened that during the rest of the rainy season of [illegible], the floods that came down the River were passed down the Canal Channel with the greatest ease, and in so far our arrangements were crowned with the most perfect success.

By a concurrence of unforeseen failures in the manufacture of materials, and chiefly in the deprivation of European superintendence arising from sickness, the new works which

during

during the following cold weather had been in progress for the protection of the Weir, were only imperfectly finished when the rains of 1852 set in. These rains commenced with unusual violence, and on the 23rd of June a heavy and continued fall of rain confined it appeared to the upper part of the Doab, led to the whole of the rivers connected with the Jumna being flooded to an enormous extent; the upper dams built for the protection of the Sluices at the Head works, were either wholly or partially removed. The floods swept over the works and carried away the whole of the central portion of the Dam, leaving the side abutments standing, with a gap between them of 150 feet in width. Fig. 2.

This removal of an obstruction to the course of the current, led to an entire revolution in the bed of the River. The abrupt step which I have before described as formed at the tail of the Dam by a succession of retrogression of levels was entirely obliterated. The bed of the River after the flood had ceased, had assumed one uniform slope, and thrown a deposit over a portion of the Masonry tail (that from the lowness of its position had not been affected by the action of the floodwaters) of no less than 12 feet in depth, is found. A careful inspection of the plans and sections of the Nowrung River with the different levels that the bed occupied

12

1st at the period when the works were constructed; 2ndly at a period antecedent to the occurrence of the accident when the retrogression of the levels on the tail had arrived at their maximum; 3rdly the state of the bed after the accident, (see Diag V. Fig: [illegible]), will be suggestive of interesting reflections on the nature and circumstances under which our canal works are placed in connection with these mountain torrents.

In comparing the effects at the Rampoor with those at the Nogong works, we see in the first case, an open or an escape inlet with its sill placed 2 1/2 feet below the natural bed of the river, & at such a depth that the action of the current passing over the surface in its natural state would not in any way have interfered with it; in other words, that the regimen of slope and soil would not by the construction of the inlet have been interrupted: we see the torrent pouring its waters over this inlet upon a lower level, artificially excavated as an escape, the slope of which was reduced far below that which nature had designed for it. In the case of the Nogong Dam, the sill of which was on the natural surface of the bed of the river, and consequently destructive to the regimen of the flow of current over a sandy bed, we see a torrent pouring its waters over an escape upon a depressed line of levels, as much opposed to its natural distribution, as that on the artificially

Excavated

excavated outlet in the Ranipoor River; we see the obstruction of this Dam on the Nogong River evidently removed, and no sooner does Nature assert her own influence than she at once returns to her uniformity of slope, ~~and~~ There can be no reason for doubting that although our experience of the effects of this accident at the Nogong Dam, only provided to ~~that~~ is one rainy season; a succession of floods would by a succession of deposits have restored the bed to its original levels as shewn by the upper line in the section, precisely in the same way in fact as the succession of floods at the Ranipoor has acted in the restoration of the levels to their natural uniformity. —

The question might, perhaps, have been one of degree in so far that the proximity of the Ranipoor works to the mountains and the excess of slope upon which the Torrent runs at the point of intersection with the Canal, would have effected in one season, that which under ~~the~~ peculiar circumstances both in distance from the Hills, and reduced slope of the Torrent might not in the case of the Nogong Excavations have been effected in many years. In both these cases the natural effects arising from artificial causes appear to me to be very much the same. —

The consequences of building masonry

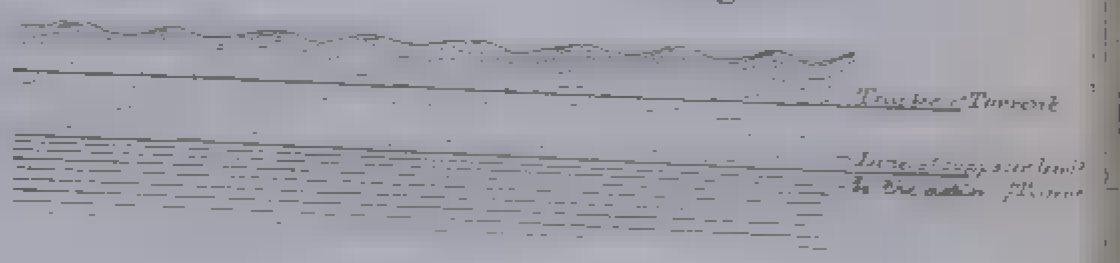
[illegible] wash
the [illegible] mountain [illegible]
running [illegible]
the banks of the [illegible]
[illegible]
formed [illegible]
and [illegible] the [illegible] of
the bed of the [illegible]
lower side [illegible] instance [illegible]
these lines [illegible] deposit
[illegible] sands [illegible]
[illegible] surface of
the country, the [illegible]
the [illegible] maintained [illegible]
[illegible]
[illegible]
11½ feet [illegible]
depending on a natural system
which [illegible] of
of deposit [illegible]
[illegible] destroying
[illegible] placing a bar
or [illegible]
[illegible] distances [illegible]
[illegible] a [illegible]
than the natural bar, opened
the bed of the river [illegible] might
naturally be expected, to result in a dis-
[illegible] of the [illegible]
of deposits below the bar, and in
~~[illegible]~~
a [illegible]
the [illegible] (given to the current [illegible]) [illegible]
[illegible]
[illegible] area [illegible]
avoidable.

[illegible]
on the [illegible] ~~[illegible]~~ [illegible]
to the following [illegible]
[illegible] a [illegible] course of
a mountain [illegible]

[illegible]

on a sandy bed

Diag VI

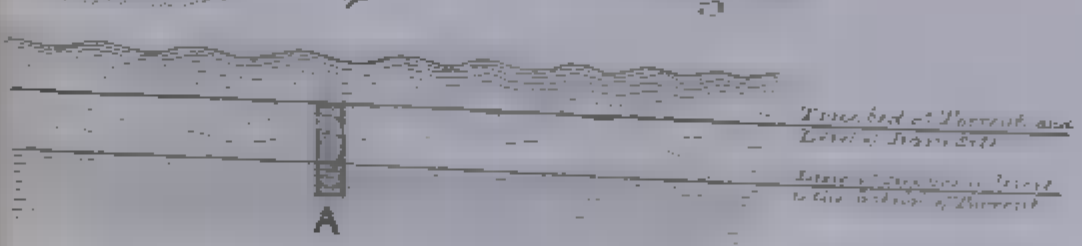


From the above diagram it will be understood that during the action of a stream the upper surface of the bed is under a forward movement and the upper strata of sand of which the superior of the bed is composed, is dislocated and torn up by the violence of the current, and that during floods the sand and water are carried forward in a rolling course to the lower beds, where it is either deposited by lateral inundations or by meeting with a basin running on a diminished slope; or, as is frequently the case with the torrents in the North west, by its joining the great Rivers, in the advancing volume of which its sands are engulphed. The above is a representation of a Stream in its natural state and its action upon the sandy bed as above shewn is I think undisputed.

Repeating the above diagram and introducing the disturbing element caused by a bar of masonry, or by the dropping and building of a Dam, the position of which is graphically shewn in the diagram, we appear to arrive at the following con-
-clusions

…cessions.

Diag: VII.



1st That the depression upon bar A must necessarily act as a disturbing element in the uniform arrangement of the sand; and that at this particular point during the periods of floods, the [illegible] [illegible] [illegible] depth to rise over the bar A leads to an increased velocity on the downstream side, which [illegible] [illegible] [illegible] the action of the current on the bed, and that this ~~[illegible]~~ [illegible] ~~[illegible]~~ small as it may be, yet [illegible] as it is with the ~~[illegible]~~ [illegible] of the [illegible] regime of the sand, places the bed of the River on the downstream side of the bar, under an entirely different regime to that which exists on the upstream side, and that this difference of regime is in favor of a [illegible] and [illegible] upon the bed of the River above the bar.

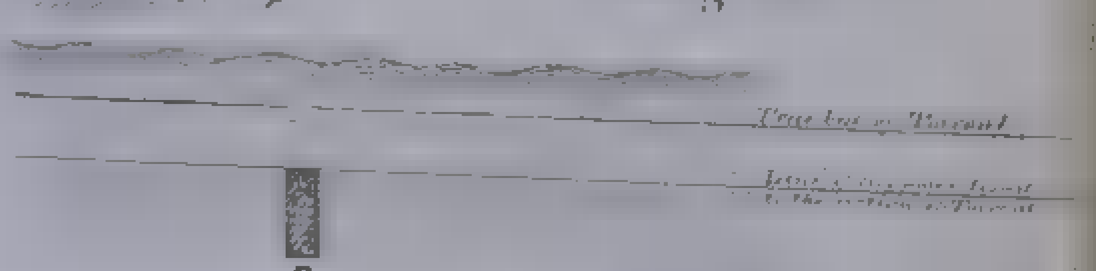
2nd That in the case of the [illegible] on the [illegible] and Nogung Rivers, during the 6½ to 9 months when the

beds

beds of the Torrents are dry, the leakage through the Dams, and the discharges of surplus water, can only aid in carrying matter forward, and the slopes upon which this advanced movement is effected are on such an exaggerated scale, that the lowering of bed and consequent retrogression of levels are inevitable.

Another and a final representation given as a diagram is illustrative of the effects upon the bed of a torrent when the Sill of a Dam or bar of masonry is placed somewhat below the line marked as that of "the supposed limit to the action of Torrent," and its introduction here as illustrative of a matter that will hereafter follow, is convenient.

Diag VIII.



B

The Sill of the Dam B is here supposed to be below the limit of matter in motion, and beyond the influence of the action of the current; its existence, therefore, is harmless as far as disturbing causes are concerned, and as it in no way affects the natural habits of the river, its admission under any form or shape is legitimately safe, and this safety increases with the depression of the Sill below "the line of supposed limit to the action of torrent."

The

The extraordinary accumulations of sand which were attendant on the floods of the Ranipur and Puthri Torrents with which we had to deal on the Ganges Canal works; and the ~~superjacent~~ action which they appeared to exert on the surface of the country, gave out new considerations as to the method of dealing with them. The alignment of the Ganges Canal came in contact with these currents at points high up on their courses, and in regions where in escaping from confined channels they formed over the surface of the country sheets of sand. Across these extensive ~~[illegible]~~ spreads the line of canal had to pass under the difficulties of its bed levels being in one case 12.7.5, and in the other 9.5 ft below the surface. The circumstances under which the Jumna canals came in contact with their torrents was in no way coincident. The line of the Ganges canal on its course between the Ranipur and Puthri torrents was literally useless unless other means than those originally devised, were projected, a catch drain of very imperfect dimensions for the silt brought down from the mountains by the periodical floods.

It was evident in fact from the experience that we had acquired during the Ranipur works during the floods of 1849, that the quantity of sand ~~that would be~~ annually brought into the Canal channel under the projected plan of works would

would be enormous, and that an influx of silt equal in extent to that of 1869, if it be annually expected in each of the ^two Torrents, ~~viz: the Ranipoor and Puttre~~, would not only lead to the great-est expense and annoyance always, but that in the working of the Canal the evil would be unbounded.

The only efficient remedy that suggested itself for overcoming the difficulties arising from these silt bearing Torrents, ^was one which from the enormous expense ~~that would attend~~ upon its adoption, and from the time and labor that would be required to complete it, was naturally ~~antagonistic~~ ^open to reasonable ~~recommendation~~ ^objection: it implied ~~a cutting out~~ ^excavation from the low ends in the Sulmow valley, back to the Puttre, through the head of the Springs (which I have before described as existing in the Budshahpoor nulla) ~~and~~ on a distance of no less than 3 miles. It implied a similar operation, under more favorable circumstances, with regard to springs in a line of ^few miles in the Ranipoor valley, and it necessitated a total and complete redistribution of the masonry works, and what was of ^equally material consequence, ^besides a complete re-arrangement of the drainage. The plan of passing the Ranipoor and Puttre Torrents over the Canal ~~which appeared to be the only remedy~~, might be compared to a design for disposing of the

rogeny

Nogong and Mushuna Rivers over the Eastern Jumna Canal by a similar process, in which the low levels of the Budna falls in the case, and the low levels of the Bobyl and [illegible] falls in the other, would be carried back to points up the Canal channel above those rivers intersection, well the [illegible] of the Torrents.

Before any determinate measures could be recommended so seriously affecting the amount of the original estimate, as the remedy to which I have just alluded, would lead to, it was necessary to examine with a mind as unprejudiced as possible the existing causes and effects of the sand deposits, bringing to this examination our experience on the Jumna Canals; that which we had so lately ~~had~~ in the case of the Ramgunga [illegible] ~~[illegible] the Ganges Canal [illegible]~~, and the general question as to the method that could be most adopted, in meeting the difficulties of the Falls in their existing state of progress. –

The question was thus brought within defined limits, and it appeared to me, to resolve itself into the following argument. –

The natural law by which the Phenomena alluded to were guided, was to be explained on the principle which was well known as operating on artificial lines of Canal both in these Provinces and elsewhere, when the early

early part of the course of the channel runs on extreme slopes through deep sections excavated through a light sandy soil, and which was inadequate to withstand the attrition of the current. The phenomena here alluded to, have not been particularly exhibited on the Eastern Jumna Canal to require any further consideration; they are important evidences of that law in nature, which enables running water to regulate its own course and its own declivity: thus in running rivers being most apparent in tortuosity of direction; in artificial lines (where tortuosity is prevented by embankments) in the adaptation of the bed or declivity of channel, ~~to meet~~ to deposits of silt or the regimen due to velocity of current. -

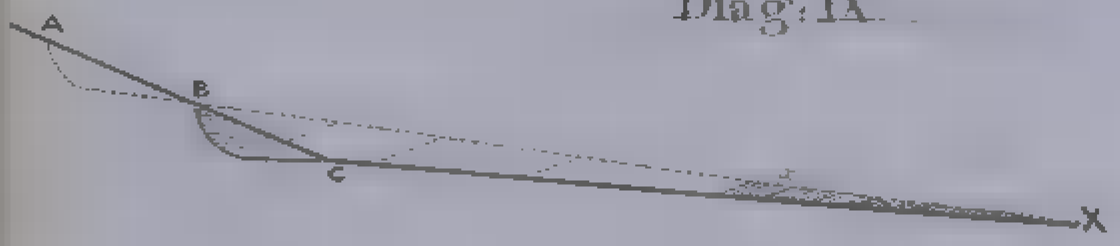
The Eastern Jumna Canal affords a good exhibition of the law in artificial lines. -

The upper or northern portion of this Canal was excavated on an excessively steep slope, in a light and sandy soil; the lower or southerly portion on irregular and moderate slopes, and through good firm soil. The results of this distribution of slopes were after a very limited period shewn in a manner unmistakeable by the following diagram, where the black line ~~represents~~ the original bed upon which the Canal Channel was excavated, and the dotted red line the slope which the current adapted itself

to

to

Diag: IX.



The process by which the new slope was arrived at is thus explained. The velocity of the current led to an abrasion of the bed at **BC** represented by the shaded portion in the diagram. The soil thus abraded was carried forward until by a decrease of the velocity of the current, arising either from diminution of slope or from decrease ~~to~~ volume, the water was no longer able to retain the matter in suspension and at the point x the ~~original~~ first deposit established itself: in the rear of ~~x, or in the rear of~~ this deposit, a stillness of water, added to the causes before mentioned, led to further deposits, and by a gradual, but very evident process the whole space **XCBx** was filled by deposits retrograding from **X** to **B** as shewn by the black dotted lines.—

A further retrogression in the wear and tear at **A** in the canal bed, led to a deposition again in advance of the point **X** with an after process corresponding in every respect with that before explained: this continued until the retrogression at **A** was put a stop to by the intervention of masonry works built for the purpose. For the particular object of the present argument, there is

no

no necessity to carry the explanation further, but it is sufficient in illustration of the effect of silt loaded waters, running on irregular slopes in an artificial and embanked channel.

We will now consider a case where the Channel has no Embankments, and where the water, presumably loaded with silt, flows over the surface of the Country.

It is clear that the precise point x at which the deposition commences, is necessarily determined by the power of the water to carry silt forward; in an embanked channel this power will act to a considerable extent only being checked only by a decrease of volume (arising from evaporation or from expenditure on water courses heads) or by decrease of the slope. In rivers not embanked the water from spreading over the country is immediately subjected to a reduction of velocity and consequently an immediate inclination to get rid of all heavy matter by deposition; the point x will therefore, in this case be situated closer to the field of abrasion at any rate it will exist at some point or other in the course of the River, and as I have before shewn, at that point where the velocity of current is inadequate to keep matter in suspension. –

Whether therefore the Channel is embanked or not the same laws operate in both cases, the same forms are obtained by a process similar in every respect, although

although under different circum-
-stances.

In the following Diagram, using the same letters as before, is represented in plan a map of the surface of a country where the channel has no embankments and where the water, gradually loaded with silt, flows over it

Diag: X.

AC having a steep slope and CX a comparatively moderate one.

The line of River from C to X would run on a tortuous course spreading and throwing up to the right and left slight deposits as may be observed in the region of all alluvial rivers* and raising the surface of the country where unshackled by any channel or

section

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* Where a silt bearing River separates into two branches, either at different angles to the main stream, or on different slopes, that branch having the least slope or at the greatest angle will have a tendency to silt up. It is thus with the outlets and escapes from our Canals, which being on a less slope than that of the main, and in most instances being at right angles to it, have always a tendency to deposit at their mouths, to throw out cattle flats, and at these places on the right or left of the stream.

To see this in a practical point of view look at the Rajbuhas, or minor lines of irrigation courses in the Jumna Canals and the frequent clearances of silt which they require; the deposits in these Rajbuhas never extend more than 1 or [illegible] of a mile from the main stream; from a rapid deposit of coarse sand

at.

section the water by spreading would lose all power of holding matter in suspension the deposits would take the form as represented at

at the point of departure. They diminish off to that of the finest mud; the whole progress of a deposit may be observed, studied and understood by any person who will from the Rajbaha head walk down its course.

In silt bearing Rivers, the water which during floods spread over the country to the right and left the water on leaving the main Current immediately has a tendency to deposit the matter suspended in it. The disposition of the deposit depending upon the gravity of the matter in suspension, this deposit is distributed in a talus sloping out wards and away from the River. Any person travelling along the Jumna Canals where the height of the surface water is very variable and when the water is loaded with silt, will observe the deposit on the berms, and may even see the action in progress. Thus.

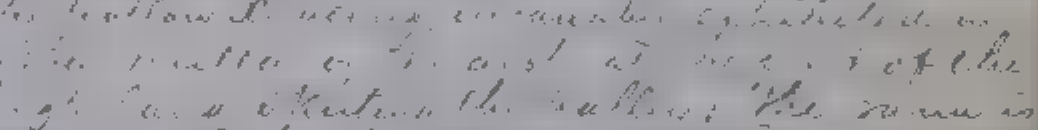
Plate XI

a being the silt deposit, and x either a lying stream or standing water.

All [illegible] is apparent in the Khadir lands of our mountain torrents only on a larger scale; the hollow x being invariably inhabited or [illegible] matter of [illegible] at [illegible] of the high land skirting the valley; the same is seen in the high steppes of the Ganges and Jumna [illegible] which although [illegible] from the [illegible] of the River which has [illegible] [illegible] for itself a course in a lower land) where a [illegible] or marsh invariably exists as [illegible] of [illegible] x: this is clearly seen in the Godanwala marsh, and in others in that neighbourhood in the Eastern Doab, as well as in the [illegible] [illegible] of Bhogpur, and similarly situated land on the Jumna.

On the Indus the most magnificent exemplification is shown of the same law over [illegible] a mile on each side of the Rivers course the land is elevated, whereas the surface of the distant country is below that of the water of the River. The following sketch for which I am indebted to my friend Major Baker of the Bengal Engineers, is literally that of an artificial Canal with embankments, the latter being composed of silt deposited during inundations.

Plate XII



The [illegible] [illegible] [illegible] [illegible] [illegible] which we point

at x, terminating in a fan shaped field of silt which would assume a convex form (as may invariably be observed in deposits of this sort) and would exhibit the remarkable appearance which is so recognizable in the Rampur and Puttree torrents, where the bed of the River after the Rains, is on a higher level than that of the neighbouring country. —

I have by black dots shewn the limits of the basin in which the floods are supposed to act; the tendency of such action being, undoubtedly, to raise the surface of the valley; the course of the preceding year would not from its elevated position be that of the next. this next flood would throw out another fan of sand laterally situated to that of the preceding year and so on annually as figured in the diagram until a deposit similar to that at x would be distributed over the whole surface of the valley; this would it may naturally be supposed lead to the same action as was before described as occurring on the artificial lines, of

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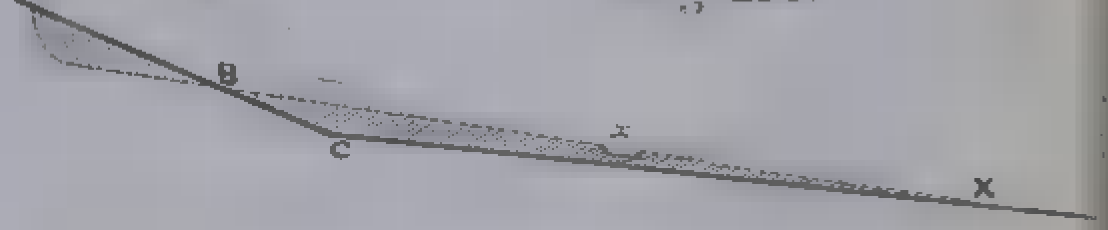
-posits assume when silt-bearing water running in a steep declivity escapes from its channel and spreads out the surface of the Country, is too conspicuously shewn at points on the Eastern Jumna Canal, where fractures have taken place in embankments much elevated above the surface of the country, to have escaped the attention of Officers in the Canal Department, but the rationale is too clear to require further explanation, when the effects of deposit depending on the velocity of the current and the gravity of the suspended matter be taken into consideration. —

of Channel, with consequences pre-cisely the same, and to use the words of a former paragraph, by a gradual and very evident process the whole space XCBx would be filled by deposits retro-grading from x to B as shewn by the dotted lines in Diagram IX.

Now, let us consider, too, the case of the Chaudwar and Puttree Torrents (which strictly deserve that name, from their being perfectly dry excepting during floods) and the deposits of sand which occur at that part of their course where the canal comes in contact with them; the valley ABC of diagram XIII represents the Siwalik hills with their steep slopes: then a perpetual tendency to aggradation from the quantities of shingle and sand which are carried out of them during every flood; and that BX is the tract of the part through which the Ganges canal takes its course as represented by the dotted lines. Now regarding the diagram as a representation of a longitudinal section through the maps in Diagram X, we have the Ganges canal at the point where excavated

Diag: XIII.



by the deposit, and actually in the position of a catch drain for the reception of all the detritus brought down from the hills AB.

It is a point, moreover, most especially worthy of attention, that the very fact of the above two Rivers being Torrents, and not perennial streams is equally in favor of deposits at their immediate debouché from the mountains: the floods are in fact spasmodic disgorgements of heavily silt laden water, spreading over the surface of the country, and frequently losing themselves by absorption and other causes before they reach the Rivers to which they are, properly, tributary.

Under the above view of the Question it appeared to be impossible that any works once situated on the point of passing flood water through the Canal could (situated as I have described the works to be both in position and level) be free from ~~[illegible]~~ extensive deposits of sand, nor would it have been practicable to maintain the Channels from the Canal out in the direction x × as open and efficient Channels without annual and most extensive clearances. Having arrived at these conclusions and being justified by the results of the floods of 1867 on the Dharijpoor works, I consider that the following facts were established.

1st That the Canal Channel under the project of 1865, would be subjected to greater deposits of sand than were before anticipated.

ticipated.

2nd That consequently, the annual outlay for getting rid of the inconveniences would be [illegible].

3rd That the whole state of the Question gave no legitimate grounds for incurring increased outlay when the object to be attained was one of such immense importance in ultimate economy.

It may be hardly necessary to observe that in illustrating the above argument neither the Diagrams themselves nor the descriptions as far as time is concerned are exaggerated in every sense: that the time occupied by Nature when nature is not interfered with in gaining the results to which I have drawn attention runs on through an infinity of ages; that thousands upon thousands of years have been expended in gaining the configuration of the earth's surface as it now exists in the region upon which the canal takes its course; that the process is so slow that human life and human intellect are incapable of appreciating it; but degradation of matter is certain; the Siwalik hills which are now such an ornamental feature of our world, will in the course of time dwindle to nothing, their substance has been for ages, and will be for another succession of ages, undergoing dispersion over the earth's surface; the land at the foot of the Siwalik hills is

Year

year after year ~~rising in surface~~ gaining in elevation as the hills themselves fall to pieces, and although the immeasurable periods at which great changes take place are not matters to be considered in human undertakings, a steadily proceeding cause is that alluded to above, in which there is a perpetual tendency to deposit, and which [illegible] me of the correctness of the results at which I had arrived in maintaining the course of the Canal and that of the hill torrents distinctly separate.

In recommending, therefore, that the course of the Ranipur and Puttri torrents should be carried over that of the Ganges Canal, I observed, that if the phenomena attendant on the regimen of the slopes of the mountain torrents at that particular point of their course where they came in contact with the Canal works, were as I had stated, it was evident

1st. That it would be an evil of the first magnitude to let these torrents with their silt into the Canal Channel.

2nd. That if a superstructure for the passage of the torrent is made of sufficient width, there will be no tendency to wear and tear on the water passing from the masonry superstructure to the soil of the slopes of the country.*

3rd.

* It was not meant by the expressions above used, that there would be no tendency to excavation at the immediate tail of the works, but that this excavation would be a mere local evil, subject to being filled in more or less on the subsidence of floods, and not one affecting the downward [illegible] of the slope.

3rd That as there is a tendency at this particular point to a deposition of silt, the torrent may be carried over the Canal with [illegible].— The advantages of passing the floods over the Canal, were in every respect undeniable, they resolved themselves into the following

1st. [illegible] [illegible] in the Canal free from silt, and the evils arising from the contact of two streams meeting each other at right angles.—

2nd. Freedom from all the labour and trouble of the [illegible] necessary to the admission of the torrent into the Canal bed.—

3rd. Freedom from the anxiety of opening and shutting the sluices, and regulating the escapes at the Dams.—

4th. Freedom from all establishment for working the Dams, and a consequent reduction of a large permanent establishment necessary for their maintenance.

On the other side was the enormous additional expense, which it was hoped would in a great measure be neutralized by the ultimate saving on Establishment, silt clearances, and annual repairs.—

In my letter of the 12th of April 1850, the arrangements depending on the improved project were thus stated

"Superpassages therefore, for the torrents will

"will be constructed on the main "channel at the Ranipoor and "at the Puttri Rao. In the first "case the 1st Fall at Bahadrabad "will be moved back to a distance "of 5742 feet (one mile and 462 "feet); in the second case the "Dhunouri falls which in the "original project are situated on "the left bank of the Rutmoo "River will be moved back to a "distance of 16630 feet (3 miles "nearly) in other words—

1st The Bahadrabad Falls "and Locks and the Ranipoor "Rajbaha outlet of the original "project will become one work.

2nd The Dhunouri Falls and "Locks and the Puttri inlet "and outlet will be united"

The general design of the works arising from this change of disposition, together with the mode of dealing with the cross drainage will be very clearly understood by a reference to the accompanying outline, which shows the details of the works from the Jowalapoor Bridge to the Rutmoo Dam both on the project of 1848, and on that which has just been explained of 1850, vide Diag. XIV.

With these outlines, as well as with the transverse sections (vide Diag. XV) explanatory of the different methods of passing the torrents over the canal channel, the reader will without difficulty be able to comprehend the precise nature of the change that had been effected, and the position of the different works as they have been actually executed.—

With

Diag. XIV.

PLAN OF THE GANGES CANAL

From the Ranipoor to the Rutmoo River

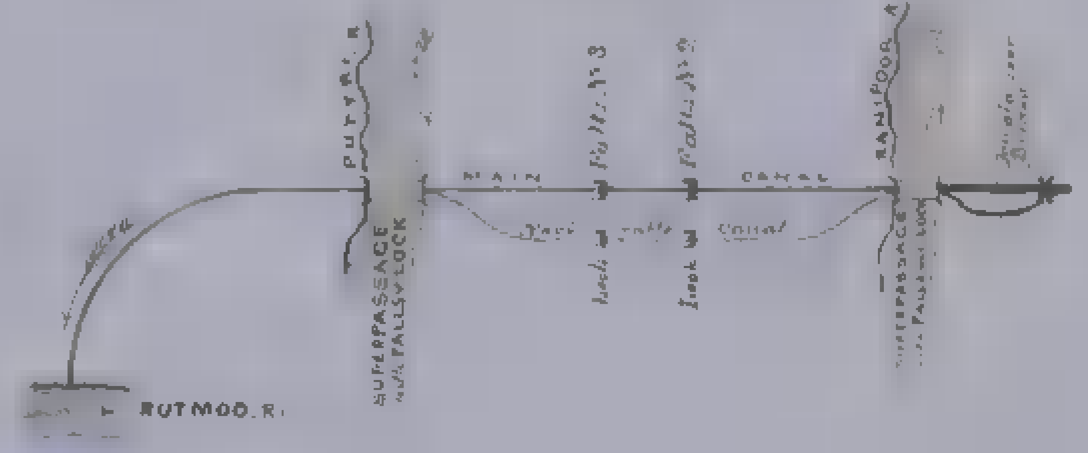
Shewing the position of the Works as originally projected in 1845

Fig. I

PLAN, *as above*

Shewing the Position of the Works as projected in 1850

Fig. II



On no Scale

Diag. XV.

Transverse Sections of the Ganges Canal, at the point where the Ranipoor (torrent) River crosses it

The blue [illegible] represent the [illegible] Stream [illegible] Ranipoor River under the [illegible] proposed.

Fig. 1

Agreeably to Project of 18[illegible]

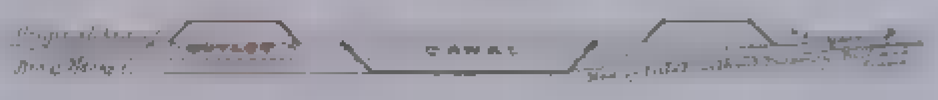


Fig. 2.

Agreeably to Modifications of 18[illegible]

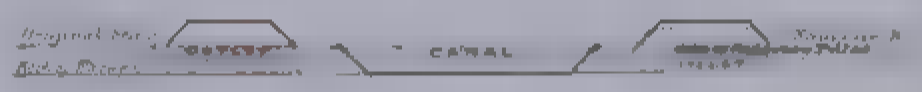


Fig. 3.

Agreeably to Project of 1850

On no Scale.

With regard to slope the head of the canal on the crest of the falls No 1 at Ramapoor was maintained on its original level; the falls which were nine feet in perpendicular descent although constructed in the form of an ogee, delivered the water on a channel 143 feet wide with a slope of bed equal to 1·052 feet per mile, and extending on a line of 9740 feet to the site of the No 2 Bahadoorabad Falls, a descent of 9 feet at this point delivered the water on a channel 140 feet wide with a slope of bed equal to 1·3' per mile and extending on a line of 2696 feet to the site of the No 3 Bahadoorabad Falls, a descent again at this point of 10 feet delivered the water on a channel of 140 feet wide with a slope of bed equal to 1·2' per mile and extending on a line of 11963 feet to the site of the No 4 Puttri Falls; from this point where the last masonry descent occurs the water is delivered on a slope of 1·21 feet per mile which terminates on the flooring of the Dhunowri Bridge.

It will be observed therefore, that the uniform slope of 18 inches which was designed in the project of 1845 was very considerably reduced, the reduction having been gained by giving an additional 12 inches to each of the masonry descents. To meet this reduction of slope however, additional width was given to the channel from the tail of the Ramapoor to the head of the

Puttri

Puttri works, south of which the interruptions which were met with from springs, led to a modification of the dimensions which were elsewhere put into practice.

The direction of the Canal was in many respects similar to that of the original project. But at the last [illegible] of the [illegible] however, there was a change of direction of 5½ degrees to the right. With this alteration ~~[illegible]~~ the Canal was carried on a direct bearing ~~[illegible]~~ to the village lands of Dhunnowri, ~~[illegible]~~. At this point the gentle curve upon which the line of Canal, as originally projected, was brought down upon the Solani River, was, for reasons to be explained hereafter, rejected; the more abrupt turn with sides well protected by masonry, [illegible] being proposed ~~[illegible]~~.

The soil through which the excavation was to be carried, was of a light description, but by no means unmixed with clay; shingle in small quantities was met with here and there, and as far as the head of the Puttri Falls no spring water interfered with the excavation. The retroposition of the 1st [illegible] of Falls led to excess of digging of 9 feet in depth on a length of 3,[illegible] feet, with its attendant

increase

increase to the dimensions of slopes. From the head of the Puttree Falls however, to the Sulimanee Rao, on which by the proposed plan an area of depth of 13 feet for a length of 1530 feet was to be excavated, the difficulties arising from spring water were very great; the detail of these difficulties will be found in its proper place when the canal excavation is brought under general review.

The passage of the Ranipoor Torrent over the Canal has been ~~[illegible]~~ by throwing arches over the lower levels of the Falls, the water way of which was divided into eight fall[?] descents of 25 feet in breadth, with a passage of 10 feet in breadth on the left for the navigable channel. The Inlet and Dam which had been already built were embraced in the side walls or abutments of this new building, so that ~~[illegible]~~ ~~[illegible]~~ the ~~[illegible]~~ masonry of the old works, ~~[illegible]~~ in the most economical ~~[illegible]~~. The superpassage which rested on the arches ~~which were~~ thrown over the noses of the Falls, has a clear water way of 200 feet in width with all the necessary appliances for its protection on the ingress and egress of the torrent.

The Bahadoorabad Falls No 2 and No 3, which are situated immediately below the Ranipoor Works, ~~were~~ are provided with a waterway of 200 feet each in 8 Bays of 25 feet each. Below the

the [illegible] on the right of the Canal at the Shamspoore inlet (which is constructed exactly on the same design as that ~~[illegible]~~ built at Sonada from [illegible]) admits into the Canal the whole of the drainage which has been before described as unconnected with the hills and subordinate to that of the Puttri; the width of waterway of the Shamspoore inlet is 150 feet.

The Puttri Super passage which is 200 feet in clear width of channel, is arranged with reference to the falls and navigable channel precisely in the same way as that before described at the Shamspoore works; all the measures applying [illegible] its protection from the [illegible] and [illegible] of floods have been carefully adopted.

On the right of the canal, at a point 1050 feet below the Puttri works, an Inlet with a water way of 50 feet in width, has been constructed for the purpose of admitting the stream [illegible] of the Badshahpoor Nulla; the design of this work is similar to that which has been universally adopted for Inlet purposes. —

The Kutmoo Dam ~~and works connected with it, consist of~~ is well protected masonry revetments for the purpose of securing a safe change of direction to the course of the Canal on its approach

to

to the River. The River is crossed by both Inlet and Outlet, and is cut off from the works on the Puttree Kulleea ridge by a Regulating bridge constructed of the same scale and fitted with the same apparatus as that at the Canal head at Myapoor. This Bridge gives the means of cross communication over the Canal on the right bank of the Rutmoo River, whilst a plain Bridge which has been built across the [illegible] portion of the Canal Channel on its approach to the Rutmoo, gives the means of cross communication on the left. The Dam is fitted with Sluices which give a water way of [illegible] feet, over the Piers heads which are 10 feet above the bed of the Canal, the works also afford a first escape for flood water equal to 800 feet [illegible].

The distribution of Escapes, [illegible] and Inlets to the Canal Channel from the Myapoor Regulator, to the Rutmoo Dam, as designed in the Estimate of 1845 and compared with those which have been adopted on the [illegible] explanations of 1850 may be thus described.

	1845		1850	
	Inlet	Outlet	Inlet	Outlet
Sounda Leni wala	20	20	50	—
Kunkul	10	—	50	20
Jowalapoor	—	—	100	—
Ranipoor — Inlet passage	131½	131½	—	—
[illegible]poor (do)	23½	23½	150	—
Puthri (do)	131½	131½	—	—
Gurh (do)	23½	23½	—	—
Badshahpoor	—	—	50	—
Rutmoo (do)	79½	79½	800	800
Totals	1136½	1126½	1200	820

In

In other words in the orig. project the whole of the drainage to the right was ~~proposed~~ to be passed off by escapes equal in width to 1126½ feet, whereas in that of the later date, the whole drainage minus 500 feet in width, ~~was proposed to be~~ passed off through 820 feet of opening. The new project ~~did~~ does, in fact, therefore, give an escape of 820 + 500 = 1320 feet or 193½ feet more than that originally contemplated.

It is questionable whether the amount of drainage which in the project of 1845, was admitted into the Canal by apertures left in the embankments would not have affected the Canal supply passing down upon the Rutmoo Dam, to an equal if not greater extent, than the numerous inlets which have been latterly designed; the admission however of so much water without any apparent escape for it, as is given at the [illegible] Nuddee, the [illegible], [illegible], and the smaller Inlets, is a more palpable evil. it is nevertheless more so in appearance than in reality, the breadth of Inlet by which in the foregoing table the amount of volume has been estimated, having been given to facilitate the ingress of floods over an expanded surface, and thereby to relieve the Canal Channel as much as possible from the effects of a confined and contracted waterway ....

With

With a view however to meet the contingency of an overloaded Canal Channel, the embankments on the left and immediately opposite the [illegible] weir, have been omitted, so that in any extraordinary rise of high water, the flood may pass over; the expedient is a [illegible] one, and in so doing the navigable Channel which runs parallel, although at some distance from the Canal on the left would be swamped; the cost however, of the restoration of this line of Channel would be trifling to the damage that might otherwise be inflicted on the main Canal works, and after all the contingency of floods of this kind occurring is one that ~~is hardly~~ hardly ~~to be~~ ~~anticipated~~ to be expected, although it is better to be prepared than otherwise.

The navigable Canal Channel which in the original project (vide the description which has been given in a former page Diag XIV. Fig 1) left the main Canal at a distance of 4000 feet from the head of the Falls, and re-entered ~~the Canal~~ it at a point below them, has in consequence of the introduction of the drainage works, been considerably modified, and very greatly improved. —

The head of this Channel (Diag XIV Fig II) now leaves the Canal on the left bank immediately above the [illegible] Bridge, which

which the works [illegible] permanent; by placing them in this situation, we have the means in our power of [illegible] the rapid discharge of any [illegible] that may pass down the Central [illegible] remains in contact with the descending [illegible] cataracts as they may be called, by which our Superfluous supply was immediately [illegible] and with [illegible] equal [illegible] to the navigation. ~~[illegible]~~.

After leaving the [illegible] runs parallel to the Canal, and reaches by a Masonry Channel ~~[illegible]~~ [illegible] a lock with a Drop [illegible] situated on the left and forming the left [illegible] Ranipur Superpassage*. After passing the Lock, the [illegible] Channel goes [illegible] and delivers the [illegible] elevated

---

* At the head of the Lock Channel at the Ranipur superpassage, the [illegible] Channel is divided into two; that on the right which is 16 feet in width serves the purposes of the Lock [illegible]; the other, that which is situated on the left, which is 11 feet in width, continuing on the upper levels under the Superpassage, for the purpose of supplying mills for grinding Corn at Bahadurabad. The intersection by this Channel of the course of the Navigable line which is situated directly below the Superpassage, a crossing is effected by an Aqueduct, from whence it proceeds to a cluster of mills, which are constructed on the site of the old Locks of the project of 1845. By taking advantage of the means at my disposal for establishing a Channel for the water under the Superpassage of the Ranipur Torrent, I was able to get a considerable supply for the mills which could not well have been obtained otherwise. —

separated Channel running parallel to and at a distance of 900 feet from the line of the main Canal, to this ~~straight and parallel~~ [illegible] the descending country which is passed in the main Canal by [illegible] and [illegible] 3 falls, [illegible] by locks of [illegible] approach the Navigable [illegible] approach to the [illegible] passage of the Pathri [illegible], [illegible] masonry channel [illegible] the superpassage and passes the descent [illegible] as I have described at the Ranipur works. ~~[illegible]~~ At this point the navigable line rejoins the parent stream.

[illegible] arrangements made for the passage of boats at the Ranipur and Pathri works [illegible] way adapted [illegible]. The masonry channel which at these points [illegible] the navigable line is entirely separated from the stream of the main Canal (with which except [illegible] supply [illegible] [illegible] has no connection whatever) not only renders the approach to the superpassages, and the descent to the locks, convenient, but places boats and rafts in their passage ~~along [illegible]~~ ~~Canal~~, out of all danger ~~[illegible]~~

I may here remark that the progress of these extensive works which the changes involved was greatly facilitated by the use of water conveyance from the Canal head downwards, and [illegible] cheap and [illegible] supply of boulders [illegible] stone which

When this mode [illegible] [illegible] introduced on the [illegible], the ~~[illegible]~~ excavated for this purpose, was a [illegible] [illegible] ten feet wide formed on the [illegible] of the [illegible] [illegible], and which a supply of water brought down from the [illegible] of the [illegible] which passes under the Town of [illegible].

My original intention was to have kept [illegible] open [illegible] [illegible] the supply of material to all the works as well as to [illegible] on the [illegible] [illegible] for which it was in the highest degree appropriate; circumstances however, prevented the carrying out of this intention to its fullest extent, and the advantages of water carriage was limited to the supply of material for the [illegible], and the works which were subsequently constructed. The benefits gained [illegible] [illegible] [illegible] this [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the difficulties and delay [illegible] [illegible] [illegible] of the highest importance, the introduction moreover of a constant supply of water in the [illegible] [illegible] [illegible] [illegible] the springs were at great depths, was certainly a great convenience to the work people in providing water for the purposes of cooking, drinking &c., but it kept up a constant supply for the brickfields, thereby facilitating the manufacture of bricks; and, finally, what was in my estimation of infinitely greater value and importance, it provided an unbounded supply

for

for the Bricklayers in laying the bricks into the work with mortar thoroughly mixed, and with bricks and mortar thoroughly moistened. The ready, although [illegible] supply of water, in fact, enabled us to ~~[illegible]~~ meet a [illegible] with the [illegible], to work at the Dam and Outlet works, the ~~[illegible]~~ water [illegible] of Springs ~~supplied~~ naturally ~~[illegible]~~ [illegible] ~~for [illegible]~~

The works, ~~[illegible]~~ from the Kanifoor to the [illegible] points, ~~[illegible] [illegible] [illegible] the best of those in the Regulators [illegible] they a [illegible] [illegible] [illegible] [illegible] Summary,~~ [illegible]:

1st The Kanifoor Supply passage with a waterway of 300 feet in width, [illegible] with Falls in 1st, 2nd a drop of 9 feet [illegible] the bed of the Canal.

2nd The Falls No 2. with a drop of 9 feet.

3rd The Falls No 3. with a drop of 9 feet.

4 The [illegible]pur Inlet, 150 feet of opening.

5th The [illegible] Supply passage with a waterway of 300 feet in width [illegible] with Falls in [illegible] 2nd a drop of 9 feet in the bed of the Canal.

6 The Balla[illegible]pur Inlet 50 feet of opening.

7 The [illegible] Dam and Inlet with escape of 60 feet and a Bridge for the purpose of regulating the Canal

[illegible] supply, and [illegible] of the canal [illegible] for its passage [illegible] towards the [illegible] [illegible] and the consequent [illegible] with a bridge for [illegible] communication [illegible] [illegible]

3 [illegible] of navigable canal from the [illegible] bridge [illegible] [illegible] passage.

[illegible] the [illegible] [illegible] bridge [illegible] high land of the Rock [illegible] at [illegible] an uninterrupted [illegible] passing [illegible] [illegible] of the [illegible] [illegible] their [illegible] [illegible] and [illegible] high land immediately to the East of the [illegible] [illegible], from thence by a [illegible] [illegible], which [illegible] at the [illegible] point of the aqueduct, the [illegible] proceeds in a straight line to the [illegible] [illegible] [illegible] [illegible] [illegible]

The deviation [illegible] [illegible] of design in this portion [illegible] [illegible] [illegible] aside [illegible] details which will be referred to in their proper place, consist entirely in a reduction to the slope of the bed; the original plan was as I have before said, to continue the slope in an uninterrupted line.

line of 15 inches per mile; from the C[illegible] to the junction of the S[illegible] Regulator, this slope has been considerably modified, and a similar modification has been granted at ~~[illegible]~~, the bed slope of the canal having been at the time which has not been described reduced to 13 inches per mile. That is to say, from the junction of the [illegible] Regulator to the junction of the [illegible] 13 inches, there is a [illegible] of a total of 15 inches per mile; according to the [illegible] (at which point it is necessary to [illegible] the [illegible] to bring under [illegible] the [illegible] of [illegible] [illegible] (already described) the [illegible] a [illegible] of 2,202 [illegible] [illegible] of 4·4 [illegible] 1095 [illegible] [illegible]. [illegible] of the land [illegible] corresponds [illegible] under [illegible]; In a general view, [illegible] [illegible] figured in Diagram II

Considering the Regulator [illegible] passes through the [illegible] of the [illegible] [illegible] ridge [illegible] land which I have before described as extending from the steep cliffs near the town of R[illegible] and terminating at [illegible], where it ends [illegible] abrupt precipices formed by the inroads

of

of the [illegible] Summit, or in un-
dulating ravines deeply and con-
siderably elevated, but the [illegible]
country which are on the sides
of it. The route on which the
Canal takes its course through
this ridge is equal to 10700 feet
the mean depth of excavation
being 31 feet and the maximum
37 feet, at the point opposite
the [illegible] an [illegible]
a [illegible] with a water
way of [illegible] dimensions
as that of the [illegible] and
hundred [illegible] with the [illegible]
[illegible] estimated, of the [illegible]
[illegible] of the [illegible]
[illegible] and [illegible]
[illegible]. The bridge [illegible]
[illegible] the [illegible]
[illegible] and [illegible] attach-
ed [illegible], and gives accom-
modation to the multitudes
that assemble during the [illegible]
of [illegible]
~~[illegible]~~ [illegible] of this place,
~~and~~ [illegible] [illegible]
[illegible] the [illegible] of
[illegible], ~~[illegible]~~
~~[illegible]~~ [illegible]
The depth of the Canal at the
point where this bridge is con-
structed is with the exception
of [illegible] the
deepest on the whole line
of works, the perpendicular
depth from the Bridge roadway
to the [illegible] on the Canal
bed ~~is~~ being equal to 37 feet; ~~and~~ there
are [illegible] arranged on
its upstream side, for the purpose
of

of ~~affording accommodation to the community~~ [illegible] with providing means of access to the Cantt. Water ~~to~~ [illegible] and also a carriage path passage to this bridge, the object being the [illegible] of rail way communication between Roorkee and the Cantonment works. This work is entirely built of brick masonry, and the foundations were in some measure interfered with by springs.

On the approach of the Canal channel to the villages of Bajooree and [illegible] the line is crossed by a hollow which is connected with an extended line of ravines ~~which~~ in [illegible] back to the distance of [illegible] into the high land, which constitutes the [illegible] ridge, the drainage of this line passed through the hollow which is intersected by the Canal, and, [illegible] into the [illegible] under the village of Bajooree; this drainage has been got rid of, by making an artificial cut from the hollow on the right of the Canal, and giving an escape to the water to the west of the village of [illegible].

From the point above described the works of the Solani Aqueduct commence, the hollow in question having on both sides of the Canal channels [illegible] it in connexion with ~~[illegible]~~ the Aqueduct terminus and passed through the Embankments

-ments; these Channels are [illegible] width 10 feet with masonry floors and flanks; they are filled in with [illegible] in a light description, and are tending to be recognized as [illegible] the [illegible] steps in [illegible] the especial object is to relieve the Aqueduct in cases of extreme flooding, and their uses will be further described hereafter. From these [illegible] may be learned.

The [illegible] [-] [illegible] stream [illegible] the upper [illegible] the Canal passes the Solani valley on a [illegible] of whose base is 150 feet in breadth, [illegible] its design and the steps as used ~~[illegible]~~ by the natives of India [illegible] bathing places, [illegible] not altogether [illegible] the Solani River is passed by a [illegible] 15 [illegible] in width each. The height of the flooring of the Aqueduct which crosses the River and upon which the Canal water is carried is 24 feet above the bed of the Solani River running under it; and this height may be considered the maximum difference of level between the bed of the Canal, and the [illegible] of the valley in the whole length upon which the Aqueduct passes.

The total length between the extremities of the [illegible] is 15687 feet, or 2 miles [illegible] 4507 [illegible] of

on which that portion of the bed [illegible] passes over the [illegible] [illegible] [illegible] is 6.30 feet [illegible] [illegible] made [illegible] and the top of [illegible]. [illegible] and = bridges [illegible] communication act as [illegible] [illegible] [illegible] the Aqueduct.

From the [illegible] extremity of Terminus at [illegible] the [illegible] passes on the [illegible] of the Doubs to the [illegible] [illegible] [illegible] to the [illegible] radius of 447 feet, this [illegible] [illegible] [illegible] the masonry of the Aqueduct, and on its [illegible] [illegible] is protected by a [illegible] of masonry which [illegible] a length of 2200 feet, the [illegible] distance from the [illegible] Terminus to the [illegible] bridge is 2110 feet in length, and the actual length of bed from the [illegible] to the terminal bridge at [illegible] to the sill of the [illegible] is [illegible] feet. The transverse section of the aqueduct corresponds ~~[illegible]~~ with that before figured in [illegible] II.

The [illegible] ~~[illegible]~~ slope upon which the channel [illegible] between the bridges at [illegible], and the sill of the [illegible] has been [illegible] with a view of protecting the bed of the channel in its course over the [illegible] valley. The flooring of the Aqueduct itself which is [illegible] feet on

the

the upper [illegible] of the Rocky
Ridge, and which corresponds
with the slope of the rocky plat-
form, ought to have been laid
8 miles above the [illegible]
[illegible] in the [illegible]; so
that [illegible] as well as
on the [illegible] of the aqueduct
channel there will be a tendency
to backwater, and consequently [illegible]
~~[illegible]~~ from the
action of the [illegible] upon the
bed, [illegible] of the
slopes which [illegible]
[illegible]
[illegible] to the [illegible]
[illegible] in the [illegible]
neighborhood, they appear to
[illegible]
[illegible]
this rather ~~[illegible]~~ delicate part of
the course [illegible]
of depressed valley.

It will be [illegible] at
this point, [illegible]
may [illegible] to the [illegible] of
the 1st Division ~~[illegible]~~ to shew the ~~[illegible]~~ view the [illegible] slopes [illegible]
[illegible]
[illegible] irregular [illegible]
[illegible] irregularity [illegible]
~~[illegible]~~ [illegible]
[illegible] they [illegible]
distinctly marked, and
easily [illegible] by the constant
recurrence of [illegible] descent,
~~[illegible]~~ Injé descents lead to abrupt changes
of level, and to [illegible] slopes quite in-

Independent

[illegible] tabulation.

Locality	[illegible]	Fall [illegible]
[illegible]	7 4889	32. 9·4

[illegible]

Locality	[illegible]	Fall
[illegible]	2 4490	24. 0·0
[illegible]	1 [illegible]	3. 5·0
[illegible]	1 4425	2. 9·8
[illegible]	1 1767	2. 3·6
[illegible]	7 4889	32. 9·4

[illegible]

[illegible] the [illegible] a [illegible] to the efficient [illegible]

Locality	[illegible]	Fall
From [illegible]	1 4882	1. 11·3
From the [illegible]	. 2692	0. 8·0
[illegible]	2 1878	2. 7·3

Brought over [illegible]	2	1878	2..7·3
From the [illegible] of the [illegible] to 3 [illegible]	2	1403	2..8·7
Totals	4	3281	5..1·0
From the Tail or lower End of the [illegible] Falls to the [illegible] or Head of the Falls at [illegible]	12	5240	15..6·1

The [illegible] of the [illegible] in [illegible]

[illegible]	[illegible]	[illegible]
From the [illegible]	3	149	3..8·5
From the [illegible]		1429	0..5·5
From the [illegible]	1	1393	1..2·9
From the [illegible]	1	3349	2..3·7
From the [illegible]	2	614	3..6·9
From the [illegible]		3404	
From the [illegible]	4	82	4..4·3
[illegible]	12	5240	15..6·1

[illegible] position of the [illegible] through which the [illegible] must [illegible] [illegible] And [illegible] the [illegible] the [illegible] [illegible] the [illegible] [illegible]; [illegible] [illegible] and the [illegible] [illegible] [illegible] [illegible] [illegible] from [illegible] the [illegible] [illegible] and the [illegible] of the [illegible] [illegible] [illegible] [illegible] clay, similar to that which is produced in our ponds and reservoirs; the same species of soil existed on the opposite and

Favorable

[illegible] [illegible] [illegible] valley, the
Canal [illegible] [illegible] [illegible]
its passage through [illegible] [illegible] of
horizontal [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible].—

Both the [illegible] of the Solani
Aqueduct and the [illegible] works
there are [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] K[illegible] to
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] a [illegible]
[illegible] [illegible] [illegible] has
[illegible] [illegible] [illegible] solidation
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] which
[illegible] gradually deposited on
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] course of [illegible]
[illegible] [illegible] [illegible] which
[illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] remainder
[illegible] [illegible] that although the
[illegible] [illegible] [illegible] on the
[illegible] [illegible] [illegible], [illegible]
[illegible] [illegible] [illegible] [illegible]
importance [illegible] lands
being high on the right bank
of the Ganges [illegible] [illegible]
[illegible] [illegible] the Districts of the
[illegible] [illegible] well drained
[illegible] [illegible] [illegible] [illegible] the
introduction of water. For the
accommodation of these lands,
heads for irrigation have been
provided both at Kunkul and
from the Mill reservoir at
Bahadrabad, and although
[illegible] [illegible] thought it expedient
to build heads for irrigation at
these

other points the means of irri-gation can very easily be obtained with greater practical advantages, if provided in after

~~[illegible]~~

[illegible] II

II The country from [illegible] to [illegible] great [illegible] the [illegible] with "Tobacco [illegible] and [illegible]"

It was necessary to make [illegible] the slopes [illegible] been, and their effects upon the [illegible] fully [illegible] review, the [illegible] that portion of the land extending [illegible] miles from [illegible] to the [illegible] Also [illegible]; [illegible] is a matter of [illegible] importance and it is as well to keep it in consideration [illegible] the [illegible] so [illegible] as that [illegible] that [illegible] the [illegible] and [illegible].

From the [illegible] that exists 20° [illegible] water, taken for irrigation [illegible] the [illegible] and the [illegible] that (from its proximity to the Savage River) we have [illegible] any quantity of water that may be so taken, without interfering with the [illegible] calculated supply for the

the [illegible] requires[?] we may consider that at the head of the district under description of which we are about to write, the supply of water is equal to 6,160 cubic feet per second, or to that which is the theoretical quantity assumed [illegible] the [illegible] supply [illegible] [illegible], without [illegible] detriment from either natural or artificial causes. At any rate as this is the specific quantity upon which the capacity of the [illegible] and means of irrigation have been provided in advance of Roorkee, it is necessary for a perfect understanding of the subject that the above quantity should be not only admitted into the canal and [illegible] on the high land above mentioned, but that its [illegible] should be admitted by those who are either directly or indirectly interested in the truth or accuracy of [illegible] calculations. The length of [illegible]

The length of [illegible] which is included in the section under description or that from Roorkee to the Village of [illegible] is 160 [illegible], its [illegible] both on the [illegible] of 1845 and on that which (arising from a redistribution of the branches south of it) was afterwards determined on is in every respect similar, considerable modifications to the slopes [illegible] and to the capacity of the [illegible] arising from the reduction of slope, and from the redistribution of the supply for irrigation [illegible]

[illegible] the irrigation [illegible] [illegible] the supply [illegible] [illegible] by [illegible] [illegible] [illegible] of [illegible] [illegible] the [illegible] of consideration [illegible] [illegible] by [illegible] to

[illegible]

[illegible] to changes in the beds but the direction of the canal alignment is ~~[illegible]~~ ~~the same~~ in both cases.

The point of the [illegible] throughout the whole of this section a [illegible] slope of [illegible] equal to 1.2 [illegible] per mile; the subsequent slope was disposed of ~~in~~ in four descents of [illegible] feet each, in masonry falls situated at [illegible], [illegible], Belra, Jauli and Chitoura; the ~~[illegible]~~ water way at each of these falls consisted of six bays of 25 feet ~~each~~, or a total ~~water way~~ of 150 feet ~~in width~~. For the passage of [illegible] descending lines of navigation, channels separated from the main ~~channel~~ were designed, the departure of which from the Canal and the point of admission to it again were situated as far as possible out of the influence of the increased rapid current due to the proximity of the falls; these lines also were fitted with locks for the convenience of ascent and descent of boats and rafts in their passage ~~to~~ the Canal; and the bridges were designed with towing paths situated under the ~~[illegible]~~ arch, in prolongation of the berm which acted as a towing path on the [illegible] line of the excavated channel.

At a point near the 50th [illegible] mile of the course of the main Canal, [illegible] near the town of Jauli

Canal a branch was to be taken off from the left, for the purpose of irrigation of the lands lying between the Eastkalie Nuddee and the Jumna River, and at the 110th mile it was proposed to take off another branch on the right for the irrigation of lands in the neighborhood of [illegible] in the Allygurh District.

The original project then, as will be perfectly understood from the above short explanation, consisted in the [illegible] [illegible] review of.

1st A line of canal with a declivity fixed to an uniform slope of 18 inches per mile.

2nd Four masonry [illegible] of 130 feet and [illegible] elevation [illegible] [illegible] of [illegible] [illegible] for the purpose of overcoming the [illegible] [illegible].

3rd A branch for the irrigation of the [illegible] District situated on the left bank of the canal and at the 26th mile [illegible] with a [illegible] head at the point of departure from the main canal.

4th A branch for the irrigation of the Boolundshuhur and Allygurh districts situated on the right bank of the canal and at the 110th mile [illegible] with a masonry head at the point of departure from the main canal.

5th Bridges situated on an

average

[illegible] 3 miles,
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
6th [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
about [illegible] district, [illegible]
[illegible]
[illegible]
[illegible]
[illegible] the distribution
[illegible] supply [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
13th [illegible] fact,
upon which [illegible]
[illegible] introduction [illegible]

diagrams

diagrams here with a few ex-
-planatory remarks derived from the
direct letters [illegible] in [illegible]
[illegible] in the mat-
-ter of the portion that lies in
advance of Hanover, will enable
the reader to form a comprehensive
view of the causes which led to
the change made above that point.

It will be recollected that
there was considerable doubt
existing at an early period
of the history of the canal
whether the direction of the branch
as laid down in the original
project through the Hampton
District, would be ~~[illegible]~~ [illegible]
~~[illegible]~~ [illegible]
~~[illegible]~~ the [illegible] of Canal Na-
-vigation. The project above re-
-ferred to placed the [illegible]
[illegible] running parallel
to and on the top of the [illegible]
[illegible] until it reached [illegible]
near the village of [illegible], from
this [illegible] a [illegible] was
[illegible] to the [illegible]
from the point of departure of
the [illegible] the [illegible]
upon which the [illegible] of this [illegible]
[illegible] had been drawn
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] heretofore ~~[illegible]~~ [illegible]

To

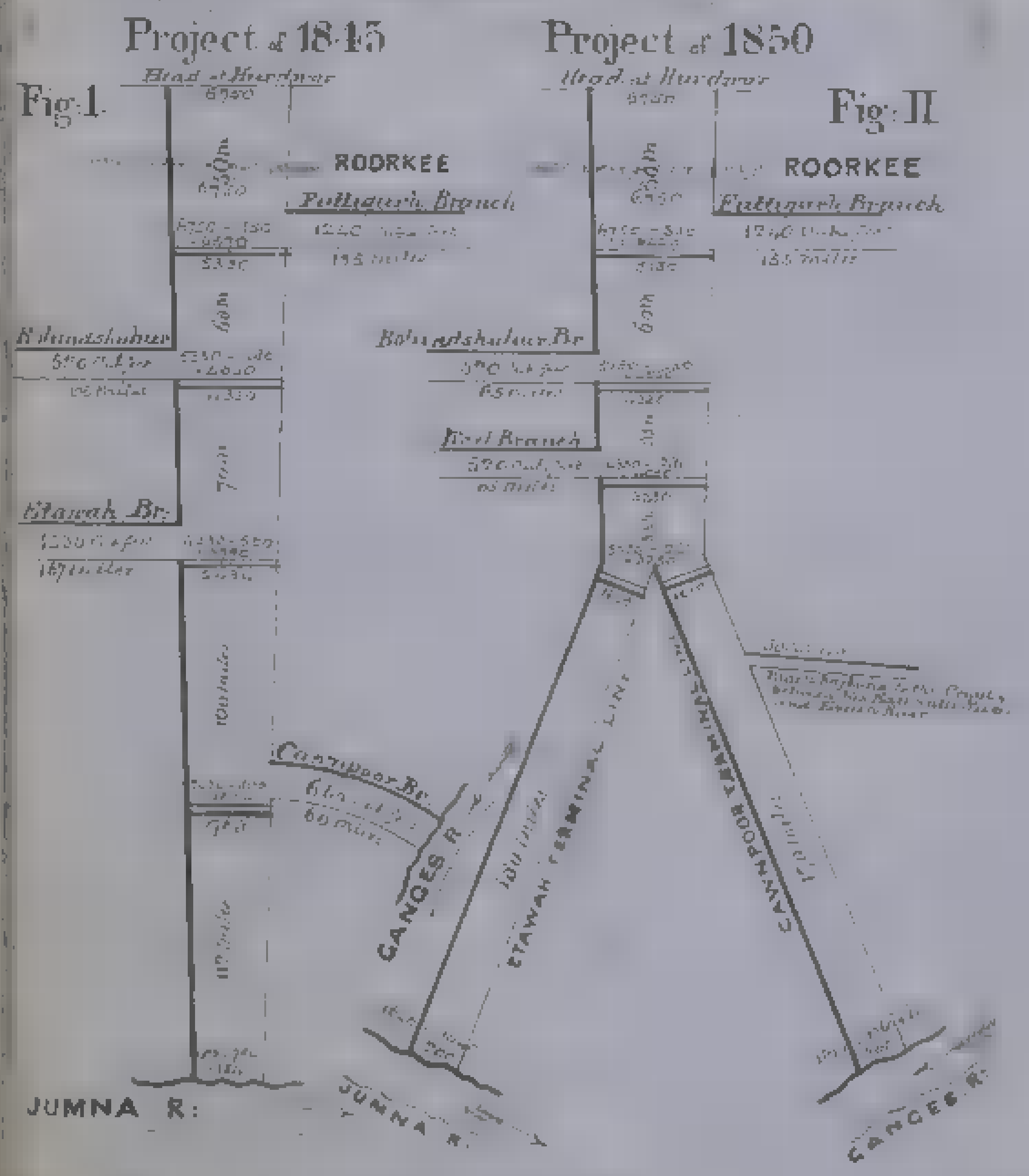
[illegible]

Map showing by the Dark lines the course of the Ganges Canal
A. Head of Futtegurh Branch
B. do Bolundshuhur do
C. do Koel do
D. do Cawnpoor and Etawah
Terminal Lines
Saharunpoor
Hurdwar
ROORKEE
Meerut
Delhi
Bolundshuhur
Koel
Futtegurh
AGRA
Etawah
Cawnpoor
Futtypoor
ALLAHABAD

[illegible]

which the above is a [illegible]

Fig. XVII.



[illegible] together with the [illegible] the [illegible] ... 100 miles [illegible] ... passing through [illegible] land in the early part of its course, and deep digging [illegible]

[illegible]

[illegible] Main [illegible] Canal [illegible] Figure 1. [illegible] [illegible] 130 [illegible] 5 [illegible] feet [illegible] between [illegible] about [illegible] 330 [illegible] feet $-70 \times 3 = 3770$ [illegible] feet. [illegible] 131 [illegible] [illegible] proposes [illegible] [illegible] [illegible] [illegible] Canals.

It [illegible] a comparison [illegible] diagrams [illegible] that [illegible] period [illegible] [illegible] [illegible] especially [illegible] the [illegible] Branch [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] this [illegible] continued [illegible] Trunk [illegible] 180 [illegible] village of [illegible] District [illegible] point it separates into two branches, [illegible] [illegible] [illegible] [illegible] the right [illegible] first [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] which will leave the main Trunk [illegible] the purpose of [illegible] the country [illegible]

[illegible]

"of Rock Cuttings, Engaged
"on a portion of the [illegible]
"District, [illegible] ad-
"-joining along the Road 13 [illegible]
"[illegible] to the East
"[illegible] and the lease
"will be pretty [illegible] from
"a few [illegible] on the [illegible] by a
"[illegible] theoretically
"[illegible] ~~[illegible]~~ [illegible]
"given, and [illegible] from the
"[illegible] from 13 [illegible] the agreements
"[illegible] the [illegible] the latter being
"a question for after consideration
"and design [illegible]."

The above is a [illegible],
but its introduction at this place
will be [illegible] great
degree, the [illegible] matters
directly connected with the [illegible]
of works [illegible].

One of the first points that
attracted my attention in [illegible]-
ing the [illegible] in
1863, was the result of the ex-
-cavations so far as they had been
carried on [illegible] from
Roorkee downwards, with the
exception [illegible]
of [illegible] the super-
-ficial soil was [illegible], in some
places [illegible] quality,
and [illegible] character [illegible]
equal to that which we had met
with in the excavations on the
Eastern [illegible] Canal lying
on [illegible]: this char-
-acter, however, ~~[illegible]~~ proved to be
entirely deceptive, the good soil

merely

me... [illegible] considered, and through-out the whole course of the exca-vations, this sand had been laid bare to an extent that rendered the question of the origin of the bed and the action of the different waters [illegible] also pro-[illegible], other [illegible] for consider-ation. The design of [illegible] [illegible] circumstances [illegible], but its maintenance [illegible] artificial expedients [illegible] means [illegible] impossibility [illegible] expenses [illegible] extraordinary [illegible] this [illegible] the case when the water was brought [illegible] with sand, or with the lighter varieties of soil that the admission of sand [illegible] the design for the [illegible] works [illegible] considered appropriate to a chan-nel when although the [illegible] [illegible] durability [illegible] of foundation [illegible] soil. The [illegible] not only in [illegible] water [illegible] but the depth and solidity of foundations [illegible] under this [illegible] appeared, and although from the advanced state [illegible] of the works [illegible] the neigh-bourhood of [illegible] and [illegible] a [illegible] of [illegible] became [illegible] incon-venient, as necessitating an alteration of work which had already been done [illegible]

at

at once to remodel the whole of
the slope on a gradient of 3 feet
per mile preliminary to its
location, as well as the water
ways of the bridges and falls, and
to provide for all the contingen-
cies which the construction of such
and extensive work would demand,
and the protection of towns under
such circumstances called for.
But a very [illegible] attention to
careful calculations [illegible] [illegible] dial
execution, and although the
whole line had been accurately
determined, a point [illegible]
[illegible] [illegible] ascended up to the [illegible]
of the Assofnuggen, after many pre-
upon, [illegible] while [illegible] [illegible]
series of designs was to be commenced.
Assofnuggen was considered to be
a [illegible] of a good and commanding
[illegible] [illegible] [illegible] [illegible] been
[illegible] [illegible] of [illegible]; it was
[illegible] situation to [illegible]
[illegible] advantages, and it was pro-
bably the point in the course
of the canal [illegible] [illegible] under
any circumstances, the subsequent
navigation would [illegible] require
its [illegible] The site of the
Assofnuggen bridge, which was
originally intended as a line
of Country cross communication,
was fixed upon, therefore, as the
starting point for the new series
of levels; a datum 4 or 6 feet below
masonry was then established,
and its upper plat[illegible] [illegible] [illegible]
[illegible] determined as fixed datum
[illegible] with reference to the
[illegible] of the [illegible] Aqueduct)
[illegible] [illegible] a zero point whence
the

the [illegible] was [illegible].

The [illegible] of the slope of the canal being [illegible] 1.15 inches per mile [illegible] a [illegible] small [illegible] of falls to [illegible] the superfluous slope of the [illegible] [illegible] disposed of, [illegible] to [illegible] the [illegible], but the [illegible] was [illegible] upon [illegible], [illegible] suffering [illegible] districts; & [illegible] the [illegible] ~~[illegible]~~ the districts of [illegible] and [illegible], ~~[illegible]~~ [illegible] [illegible] great [illegible] with the [illegible] of the canal [illegible] it reached the neighborhood of the flats on which [illegible] use; at this point a [illegible] abrupt descent [illegible] the surface of the [illegible] [illegible] descent to [illegible] levels.

The project under this [illegible] plan consisted of an uninterrupted slope of 1.5 inches per mile, with [illegible] descents at the following places

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	5	200
[illegible]	[illegible]	8	200
[illegible]	[illegible]	5	200
[illegible]	[illegible]	5	200
[illegible]	[illegible]	5	100
[illegible]	[illegible]	8	100
[illegible]	[illegible]	5	150
[illegible]	[illegible]	[illegible]	100
[illegible]	[illegible]	5	100

a [illegible] [illegible] [illegible]
ov[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] ~~[illegible]~~
~~[illegible]~~ [illegible]
~~[illegible]~~ [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] ~~[illegible]~~
[illegible] ~~[illegible]~~ [illegible] ~~[illegible]~~
a [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible]
of the [illegible] [illegible] [illegible]
[illegible], [illegible] [illegible]
quantity [illegible] ~~[illegible]~~,
~~[illegible]~~ [illegible].

Additional [illegible] was
obtained [illegible] [illegible] [illegible]
towers [illegible] [illegible]
a [illegible] [illegible] [illegible]
Bridges as they were [illegible]
[illegible], and the substitute [illegible]
in the structure [illegible] [illegible]
a pathway under [illegible] sup-
ported [illegible] [illegible]
work; [illegible] ~~[illegible]~~ [illegible]
path ~~[illegible]~~, [illegible]
through the [illegible] [illegible]
bridge ~~[illegible]~~
~~[illegible]~~, [illegible] [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
cases the [illegible] [illegible]
of [illegible] [illegible] the works
[illegible] [illegible] [illegible]
Bridge # [illegible] # [illegible]
covered ~~[illegible]~~ [illegible]
by ~~[illegible]~~ [illegible] [illegible]
condition [illegible] [illegible]
[illegible] [illegible] Bridge masonry
protected [illegible] [illegible],
the [illegible], [illegible] these
works [illegible] protected [illegible]

[illegible]

lines of [illegible]

[illegible] a [illegible] the
[illegible] had been made
[illegible] the Canal,
[illegible] that had been
[illegible] the dif-
[illegible] all-
[illegible] to the topographi-
cal features of the country,
[illegible] distinct
[illegible]; and that this may
[illegible]
[illegible] divide the
description into sections com-
[illegible] at the mouth of the
[illegible] Bonnet Carré Crevasse

19th to 40th mile The [illegible] its passage
[illegible] and its
[illegible], makes a
[illegible] continuous
[illegible] about
[illegible] about 4½ miles,
[illegible] the [illegible]
[illegible] this [illegible]
it runs parallel [illegible] between
the [illegible] the
[illegible] a
[illegible] that acts
as a [illegible]
[illegible]. ~~The~~ position with regard
to these two natural boundaries
[illegible] particul-
As a [illegible] it is [illegible]
[illegible], and in the vi-
cinity of [illegible] Point,
[illegible] approach
approaches [illegible] within 1½ miles
of the edge of the [illegible], through-
out the [illegible] of this tract the
~~[illegible]~~ surface is marked [illegible] undu-
lating ridges [illegible]

[illegible]

this [illegible] the river,
on the [illegible] with [illegible] watered
[illegible], with [illegible]
along the [illegible], ~~[illegible]~~
~~[illegible]~~ [illegible] ~~[illegible]~~
have [illegible], [illegible] ~~[illegible]~~
[illegible]
[illegible]
[illegible]
of [illegible]. [illegible]
[illegible]
first [illegible]
[illegible]
the [illegible]
[illegible]
although the land is [illegible]
[illegible]
than [illegible],
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] population ~~[illegible]~~.
There are numerous lakes
well wooded with [illegible] and
other [illegible] trees [illegible] to
this part of [illegible]
[illegible]
[illegible] and the [illegible]
is what is designated [illegible],
that is [illegible] and [illegible]
[illegible] in fertility. [illegible]
[illegible] in depth [illegible] 30
to thirty feet [illegible]
agricultural purposes, and it
[illegible]
[illegible] and
[illegible] the [illegible]
or natural [illegible], that the
[illegible] in [illegible]
is [illegible] for the purposes of [illegible]-
[illegible]

[illegible] Sugar Tree County

on

on the 20 miles running from Pooree to Balia may be estimated at 40 feet, or 2·3 feet per mile; as a general rule there is a transverse slope from the edge of the bank to the head of the tidal river, but the immediate land upon which the canal takes its course, is sometimes nearly horizontal, this is especially the case at Pooree as well as at Toghulpur and Balia where the high land lying between the ~~high~~ bank on the east and the sand ridges which run parallel to the canal on its west, has very little variation in profile. The [illegible] of canal [illegible] although keeping as close as possible to the backbone of the country must, as will be understood from the transverse slope before mentioned, interfere in some degree with the drainage ~~of the country~~; this has been [illegible] in the neighbourhood of [illegible] and [illegible] by a [illegible] made with the [illegible] of the [illegible], and it will be evident from the position in which the works are situated, right above the lowlands & which run within a few miles of them, that inconvenience & [illegible] from want of drainage can only be attributed to a want of channels of escape for the making of which nature has provided every facility. On the approach of the canal to

Pooree

where it takes up its proper position on the bank [illegible] Country.

The depth of excavation throughout the whole of the Canal, from [illegible] to [illegible], is greater than that of the calculated [illegible] water [illegible] supply, excepting in the neighborhood of [illegible], where a depression of the country [illegible] of [illegible]; the maximum depth of excavation on this depressed line is equal to 18 feet.

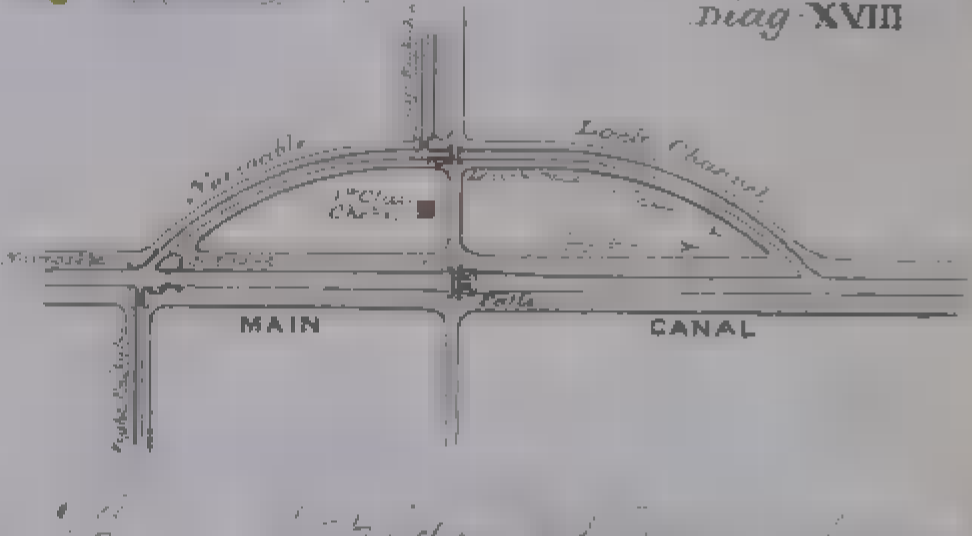
The [illegible] works will consist of:

1st [illegible] walls, with a [illegible] [illegible] navigable channel [illegible] the [illegible] at a distance of 3500 feet above the falls [illegible], and [illegible] at a distance of 1000 feet [illegible] 3000 feet below the falls, [illegible] is pro[illegible] by [illegible] with plank [illegible] on each side of the [illegible] fitted with iron rings and appliances for the establishment of a bridge of boats over the main stream, the object of this bridge being partly to prevent [illegible] passing down the canal from coming within the influence of the [illegible], partly to give a line of cross communication, and partly to give dead water

to

to both the navigable channel
and to a [illegible] or main
watercourse road which is
situated immediately above
it on the right bank. Locks
with a bridge the axis of
which corresponds with that
of the bridge over the Falls
an obstruction in the navigable
channel in the [illegible]
[illegible], or when the
Locks are connected with
[illegible] road.
For the irrigation of the Country
[illegible] Mills are
attached to the Waste Channel
[illegible]
[illegible] is built in
the [illegible] formed by the
main and navigable channels
For a full description of these
works the Atlas and the
Chapter devoted to the details
of construction must be con-
sulted, but the introduction
in this place of a diagram
[illegible] ~~[illegible]~~
[illegible]
[illegible]
[illegible] out the
[illegible]

Diag XVIII



1st [illegible] Bridge of the [illegible]
[illegible]
[illegible] this bridge has 3
Bays

[illegible] roadway of [illegible]

Bays of 55 feet each, and [illegible] [illegible] [illegible] [illegible] on the up and down stream [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

3rd Bridge at [illegible] with a [illegible] [illegible] of the 2nd class [illegible] [illegible] [illegible] as [illegible] [illegible] [illegible].

4th Bridge at [illegible] [illegible] the foundations only of which [illegible] [illegible] [illegible].

5th Cells and Tanks at Mohumudpoor [illegible] in every respect to those at [illegible] [illegible].

6th Bridge at [illegible], similar in every respect to that at [illegible].

7th Bridge at [illegible] with a [illegible] [illegible] of the 2nd class [illegible] [illegible] [illegible] as that at [illegible].

8th Cells and Tanks at Belra — similar in every respect to those at [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] XXVIII [illegible]

9th Bridge at Belra with a [illegible] [illegible] of the 1st class.

[illegible] [illegible] [illegible] [illegible] [illegible] 40th to 60th Mile of Belra, [illegible] [illegible] [illegible] [illegible], a slight turn to the right [illegible] in distance from the high bank of the [illegible] [illegible] [illegible] a more central position between that bank and the [illegible] connected with the [illegible] Kalli Nuddi, this inclination to the right or to the westward increases

on

on the approach to the Town of [illegible], immediately South of which and to the Eastward, it passes the [illegible] East Kalli Nuddee which here [illegible] separates the [illegible] from the Ganges River. The distance between the East and West Kalli Nuddees at this point is about 6 miles, through which the Canal passes [illegible] nearly diagonally.

The features of the country through which the above tract [illegible] [illegible] unlike those [illegible] before ~~described~~, [illegible] and to the west of the [illegible], and between it and the valley [illegible] of the West Kalli Nuddee runs [illegible] depression [illegible]; the foundations both of the channel and of the foundations of the Masonry works were sandy throughout; [illegible] was [illegible] difficulty [illegible] with [illegible] the early completion of the numerous and extensive Masonry buildings on this line, may be [illegible] to our [illegible] bricks from the [illegible] ruins of Chitowra and other old Towns which are the remnants of a period when the Muzuffurnuggur District was governed by Zabita Khan's family.

The longitudinal slope of country over the 21 miles above referred to, is 39 feet or 1.86 feet per mile; the transverse slope is from west to east, but the line of canal runs high and is well

situated

situation with regard to the water-shed.

From a point at the [illegible] mile [illegible] of the canal, a branch of the irrigation [illegible] [illegible] [illegible] Kali Nuddi [illegible] leaving the main [illegible] or East [illegible]; at the point [illegible] (153 [illegible]) [illegible] has been [illegible] the preliminary [illegible] [illegible] established [illegible] fixed points [illegible] as far ~~[illegible]~~ as [illegible] can [illegible] making [illegible] the [illegible] line will be found [illegible].

On the Eastern [illegible] at the village of [illegible] is situated nearly opposite the 60th mile of the [illegible] the Main Canal, the [illegible] Nuddi rises. [illegible] long [illegible] have been excavating at its [illegible] immediate [illegible] and [illegible] the hot months of the year [illegible] dry. This line of drainage, which ultimately forms a very extensive river, is [illegible] tanks [illegible] a small [illegible] Nulla, running through low, grassy and [illegible] lands; it gradually [illegible] expands ~~itself~~ and at a point in its course at some distance ~~before it has reached~~ the [illegible] Bolundshuhur it becomes a perennial stream running in a deep and well [illegible] valley, which continues increasing in size.

[illegible] a importance [illegible] pass.
[illegible] the [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible] Island
to [illegible] the [illegible] part [illegible] its
[illegible] place, [illegible]
[illegible] of the [illegible] water,
[illegible] in the [illegible], [illegible]
[illegible]
[illegible] important
place [illegible]

[illegible] of [illegible]
[illegible] 13th a
[illegible]
[illegible] [illegible] maximum
depth [illegible]
[illegible] water [illegible]
[illegible] water [illegible]
[illegible]
[illegible]

[illegible] above described
[illegible] the 13 [illegible] 13th [illegible]
the [illegible]
[illegible]

1st [illegible] at 12 [illegible]
[illegible] which
[illegible] described, with
[illegible]

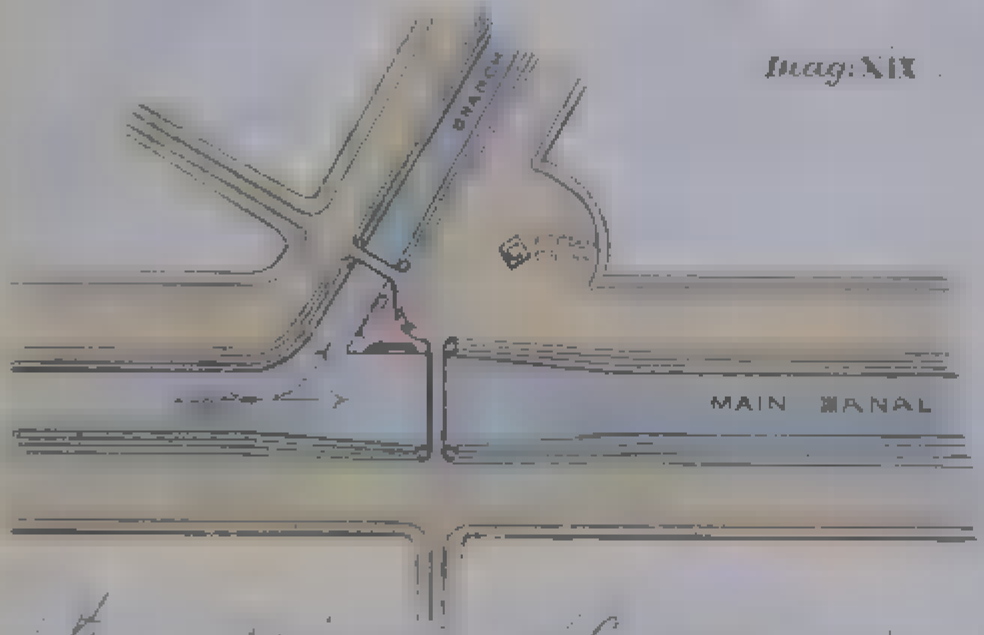
2nd [illegible]
[illegible] inspect
[illegible]
[illegible]
[illegible] is of the
2nd class.

3rd [illegible]
This work consists of a bridge
[illegible] 100 [illegible] each
[illegible] the [illegible]
[illegible]
[illegible] the [illegible]

[illegible]

[illegible] by a [illegible] of [illegible] [illegible], resting upon a [illegible] shaped platform [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]



Diag: XIX

4th Bridge of [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 165 [illegible] consisting of 3 [illegible] of 25 feet each (vide Atlas Plate 21)

5th Bridge at [illegible], [illegible] that at [illegible]

6th [illegible] works at [illegible] [illegible] every [illegible] which have [illegible]

7th Bridge at [illegible], similar to that at [illegible] under 2nd [illegible]

60th & 61st mi. [illegible] the canal [illegible] ~~[illegible]~~ [illegible] the [illegible] of the [illegible] [illegible] ~~[illegible]~~, until it approaches the [illegible] of [illegible] [illegible] [illegible] a [illegible] the south [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] & [illegible] part of ~~[illegible]~~ [illegible] [illegible], [illegible] ~~[illegible]~~ [illegible] round the [illegible] side of the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible]; the [illegible] [illegible] [illegible] the altitude of [illegible] [illegible] [illegible] the [illegible] [illegible], [illegible] its [illegible] [illegible], [illegible] [illegible] a consequent [illegible] [illegible] the [illegible] upon [illegible] [illegible] [illegible] [illegible], places the canal on a [illegible], the transverse distance between the two rivers [illegible] at this point equal to 1¾ miles. The slope of the country on this [illegible] of [illegible] [illegible] [illegible] [illegible] per mile, the transverse width varies from 8 to 1¾ miles, and the slope

side which ~~[illegible]~~ ~~at~~ the [illegible] 15 [illegible] [illegible] not [illegible] against the [illegible] position [illegible] ~~[illegible]~~ ~~feet~~ per [illegible] [illegible] [illegible] [illegible] on the [illegible] [illegible] [illegible] [illegible] Corresponding [illegible] [illegible] [illegible] a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the canal [illegible] [illegible] [illegible] description [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as well as the ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the right [illegible] [illegible] [illegible] point 102 [illegible] [illegible] at [illegible] [illegible] [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible] 60 feet in width; the distance [illegible] the canal at this point to [illegible] is 3 3/8 miles, [illegible] [illegible] [illegible] [illegible] [illegible] the canal [illegible] [illegible] [illegible] ~~[illegible]~~ feet, the weir [illegible] waste way [illegible] the [illegible] [illegible] [illegible] waste water is 100 feet divided [illegible] 10 [illegible] [illegible] [illegible] [illegible] Atlas Plate XXXVII [illegible] [illegible] [illegible] [illegible] channel

and

and at a distance from the Canal of 6024 feet the main [illegible] is carried over an Aque-duct, commenced with a bridge [illegible] to the [illegible] desert [illegible] of 8 feet [illegible], and is [illegible]; it is intended [illegible] effects [illegible] this [illegible] by building [illegible]; it has been considered [illegible] the [illegible] of the [illegible] traffic [illegible] to [illegible] this way, [illegible] of those [illegible] is one [illegible].

At the 14th mile, [illegible] the village of Cowalapur [illegible] ~~[illegible]~~ [illegible] Chhoohauri [illegible] has [illegible] paid [illegible] people [illegible] excavation ~~[illegible] the village [illegible]~~ in an oblique direction across the canal to the head of the [illegible] codara (which is the [illegible] [illegible] connected with the East Kali Nuddi which passes through the Cantonment of Meerut. At this point [illegible] 2 Coups, equal [illegible] that at [illegible] built, and [illegible] excavation of the [illegible] Canal into the Kali Nuddi [illegible]

&c

The distance from the [illegible] to the [illegible] is equal to 7 [illegible] and a [illegible] difference [illegible] from the [illegible] to that [illegible] the [illegible] is 303 feet; the width of [illegible] for the passage [illegible] the [illegible] [illegible] with [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible]. At the [illegible] [illegible] [illegible] [illegible] the [illegible] of the requisite [illegible] its situation however, is 7900 feet distant from the [illegible] a ridge and, [illegible] [illegible] [illegible] placed as it [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] with a passage [illegible] [illegible] [illegible].

The depth of [illegible] [illegible] [illegible] the [illegible] [illegible] to [illegible] is [illegible] [illegible] [illegible] [illegible]. The [illegible] depth [illegible] the [illegible] of the [illegible] [illegible] [illegible] is [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] a [illegible] [illegible] the bridge at the village of [illegible] [illegible] the following bridges [illegible] [illegible] constructed.

1st Bridge at [illegible] [illegible] the [illegible] Road [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], but with a roadway of 24 feet in width; these are [illegible]

[illegible]

a flights of steps on the down stream face of this bridge, and the upstream side is protected by [illegible]

2nd The Whitcomb Escape [illegible] [illegible] cross drainage, with 60 feet water way divided into 10 [illegible] of 6 feet each.

3rd Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water way of 165 [illegible] [illegible] 3 arches [illegible] 55 [illegible] [illegible]

4th [illegible] [illegible] [illegible] [illegible] to those [illegible] [illegible] [illegible] [illegible] [illegible] width of water way [illegible] to 150 feet.

5th [illegible] Escape with [illegible] [illegible] with 60 feet water way, divided into 10 [illegible] of 6 feet each, with a [illegible] [illegible]

6th Bridge at [illegible] similar to that at [illegible] [illegible]

7th and Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] Whitcomb [illegible] flights of steps [illegible] [illegible] in the same [illegible] [illegible] to this bridge [illegible] [illegible]

8th Bridge at [illegible] with 150 feet water way in 3 [illegible] of 50 feet each, with [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] down stream side of this bridge, and [illegible] the bridge is [illegible]

9th Bridge at [illegible] [illegible] [illegible] [illegible]

[illegible] at Nanoon, but without [illegible] near the Bridge is [illegible]

10th [illegible] village of [illegible], [illegible] [illegible] the boundary [illegible] which at this Bridge is 20th [illegible] [illegible] attached.

From the [illegible] **80th to 100th mile**

[illegible] [illegible] [illegible] and [illegible] [illegible] have the [illegible] miles of Canal [illegible] [illegible] the Canal preceding the [illegible] [illegible] it reached [illegible] what, at this [illegible] [illegible] of [illegible] for the purpose of [illegible] the water [illegible] [illegible] [illegible] to the East, [illegible] [illegible] the [illegible] of [illegible] [illegible] [illegible] miles [illegible] this description [illegible] [illegible] [illegible] Bugur [illegible] [illegible] [illegible] Canton [illegible] is situated at a distance [illegible] [illegible] the nearest point of the alignment on its right [illegible] [illegible] and Moradnuggur, the latter being within a short distance of the Canal.

The width of [illegible] [illegible] passes, measuring transversely across the Canal [illegible] the last half [illegible] and the

Hindun

Hindun River is at [illegible]
15½ miles; this increases in ad-
vancing, till at [illegible], the
canal lies in a separation
of a width of 3 miles; at [illegible]
[illegible] the canal runs con-
tinuing between the ridge boundaries
being separated from the East Kali
Nuddi by the Hindun nulla
which at this point is a mere
drainage depression; as it advances
Southward, it keeps nearer to the
Hindun from which at one point
of its course opposite Dadri,
it is separated by a distance
of only [illegible] miles; the cause of
this close approximation to the
Hindun, probably arises from the
interposition on the East of the
Chorya Nulla, a tributary like
the Hindun already described, of
the East Kali Nuddi. The Chorya
Nulla rises at a point about 3½
miles to the East of the Canal
in the latitude of Meerut, it takes
a winding direction nearly parallel
[illegible] of the Canal and joins
the East Kali Nuddi after running
through a course of 30 miles at a
point about 9 miles below the
town of Hapoor, within which
and the Canal the Chorya Nulla
passes; its character is precisely
the same as that of the East Kali
Nuddi: in the early part of its
course, an ill defined straggling
nulla running through land
all cultivated in its edges, and
excepting in the rainy months
perfectly dry; in the latter part
near its junction with the

River

River to which it is tributary, being a sluggish stream through a deep hollow with a valley more or less extended. All these nullahs are of this character, from their heads which generally [illegible] the drainage of whole tracts of country, they proceed in their course increasing gradually deeper and wider, until they reach the main river to which they are tributary. The direction of the main line of Canal there-fore, is in a great measure de-pendent on these nullas, and the lower lands which lie contigu-ous to it.

The depth of the surface of the country is about 3[illegible] feet, but averages 1.75 feet per mile; in a transverse direction the inclination is towards the East, but in such a small degree that it is hardly perceptible; the line of canal in fact is distinctly on the high [illegible] at the village of Simri [illegible], and it proceeds onwards to Sullalabad in the same elevated position. The country over which the works are carried between Tadumma and Sullalabad is on an average taken from six measurements from the Surveyors returns 143 feet above the bed of the Hindun, and 34 feet above that of the East Kali Nuddi; the Dhoya or river which intervenes, having from the neighbourhood of Bhoira (at which point its heads are on a level with the country) obtained

a

a depression of 16 feet. Cross sections [illegible] in 1841, showed that [illegible] was [illegible] feet [illegible] bed of the Hindun [illegible] and 3.33 [illegible] that of the [illegible] ~~[illegible] at the [illegible] was [illegible] from its head~~; [illegible] at [illegible]abad [illegible] found that [illegible] of the Hindun was [illegible] feet, and that of the [illegible] feet below the [illegible] country [illegible] the [illegible] [illegible] was [illegible], [illegible] [illegible] impassable [illegible] alteration [illegible] which [illegible] of [illegible]abad ~~[illegible]~~ 7.31 feet ~~[illegible]~~ which, as the distance is [illegible] miles, is equal to 1.3[illegible] feet per mile.

The country through which [illegible] ~~[illegible]~~ very [illegible] ~~[illegible]~~ a remark that [illegible] applies to the greater [illegible] [illegible] of the [illegible] south [illegible] [illegible] [illegible]alabad [illegible] 13[illegible] [illegible] are [illegible] conducted [illegible] have [illegible] previously, the [illegible] excavation is generally of a very [illegible] through a good [illegible] soil, with ~~[illegible]~~ ~~[illegible]~~ [illegible] ~~[illegible]~~. The [illegible] [illegible] opposite [illegible] where the excavation is shallow, the [illegible] depth [illegible] the ~~[illegible]~~ [illegible] [illegible] the max[illegible] [illegible] water, and on that [illegible] of depth [illegible] which the

[illegible]

-ments, these works are ~~[illegible]~~ massive and more ~~[illegible]~~ that [illegible] from breakages, nor [illegible] the penetration of water [illegible] anticipated.

At the village of [illegible] Khoord is a third weir (No 3) connecting the canal with the Hindun; this work is a waterway of [illegible] divided into 10 [illegible] of 6 feet each; its dimensions both of [illegible] and capacity of [illegible] are precisely the same as ~~that described as~~ No 1 at the site of [illegible] Khoord [illegible], and the arrangements for the passage of the [illegible] and the [illegible] of [illegible] are [illegible] on the same design. The distance from the head of the Hindun at the point where the weir is built is equal to 5¾ miles and the difference of level between the head of the canal and the bed of the river is 38.06 feet.

The maximum depth from the surface of the country to that of the water in wells by observations during the month of March is on the 10 miles above described, equal to [illegible].91 feet, and the minimum [illegible] feet.

From the [illegible] Bridge downwards the following works have been constructed.

1st Falls and Works at [illegible] similar to those which have been before described, but with a waterway over the falls of 150 feet in width as a [illegible]; there is some deviation from the original.

original design in the lining and of the navigation channel, arising from the village of Roorkee being near the alignment, in other respects the works correspond in every way with those which have been described.

2nd [illegible] Sunnekhond? & Bridge similar in every respect to the works at Roorkee mentioned above except waterway [illegible] in 10 sluices of 6 feet each.

3rd A Bridge at Dannikhood? similar in design to that at Roorkee (Atlas Plate LII) with a 2nd Class Lock attached to it.

4th Bridge at [illegible] with a 2nd Class Lock, both of them similar to that at Roorkee.

5th Bridge at Newarri? sim- [illegible] ilar to that at Roorkee with a 1st Class Lock attached.

6th Bridge at Uranda? sim- [illegible] ilar to that at Roorkee with [illegible] on the [illegible] on the up and down stream sides with a 2nd Class Lock attached.

7th Bridge at Lidroti? sim- [illegible] ilar to that at Roorkee with a 2nd Class Lock attached.

8th Bridge at Muradnuggur? similar in design to that at Roorkee; [illegible] and with [illegible] on its down stream side correspond- ing in design with those which have been built at [illegible] and [illegible] (Atlas Plate LII). To this bridge a 2nd Class Lock is attached.

A.

A further distance of 20 miles, — 100th to 120th mile

the first portion of which is in continuation of the same [illegible] having [illegible] [illegible] as [illegible] altogether, takes us to the neighbourhood of Hissar[illegible], a Town situated in the [illegible] District, the [illegible] from a point near [illegible] up to the 120th mile the Canal pursues its course in an uninterrupted straight line [illegible] [illegible] [illegible] [illegible] [illegible] rather to the west, [illegible] the Hindun side of the Doab, [illegible] this section takes an opposite course; from the point near [illegible] [illegible] the Canal [illegible] the Hindun river approaches within [illegible] miles [illegible] east of it, the Canal takes an oblique direction across the country towards the East Kali Nuddi, from which at a point a few miles below [illegible]dinabad it is only two miles distant. Throughout the whole of this length the Canal each [illegible] its course [illegible] the Hindun in the west, and the Ganga, and latterly the East Kali Nuddi (after the junction of the Ganga with it) on the east. At a point almost directly at right angles with the line of [illegible] [illegible] [illegible] [illegible]abad the Hindun [illegible] the Jumna; [illegible] the low [illegible] [illegible] of these Jumna [illegible], which [illegible] Delhi [illegible] Ghazeeoodeen-nuggur (domains) are [illegible], extend over a surface varying [illegible] 1 to 13 miles in width and [illegible]

considerably

considerably reduce the area of the irrigated land in immediate con-nection with the Canal.

The slope of the surface of the Country on the line over which the 26 miles from Jullalabad to Tikun-doulad passes is 33.75 feet or 1.66 per mile; the width may be estimated on an average at 16 miles including the land cut off by the Choiya on the East, and the Khadir lands of the Hin-dun on the West; the surface is in a general point of view flat, unbroken by irregularities un-worthy of any particular con-sideration, the direction of the canal, however, is high and on a cross section from the Hindun via Ghazeeooddeennuggur, Dasna, Salund, Kabul and Kumalpoor to the Choiya nulla, it crosses at the highest point near the village of Salund; that point being elevated 40 feet above the Hindun and 15.38 feet above the Choiya.

It was on this line, and from a point in the Canal near to Moradnuggur or Jullalabad, that in my first report written in 1840, I pointed out the probable advantage that might be derived from carrying a line of Navigable Canal to the Hindun River with a view to ascertain the capabilities of the Hindun. I had measurements (transverse) in width and depth taken at every thousand feet in length from the Bridge which crosses the River at Ghazeeood-deennuggur to its junction

within the domain ~~of the River~~ near the village of Dunkour, these measurements which were taken in the month of April showed that with the exception of one part of the course of the River near the village of Gogee, where the depth of water varied from 1½ to 13 feet, the average depth might be estimated at between 3 and 4 feet, in a width varying from 7½ to 31 feet. The total distance between the Ghazeeoodeennuggur bridge to the Hindun, and the junction of that River with the Jumna, was 30¼ miles, the course being exceedingly tortuous, and with much of the passing through ~~the~~ jhadie. A tabulated statement of these measurements will be found in the volume of Tables attached to this report. With lockage of 35 feet, or thereabouts, a line of still water might be carried from the Canal to a point on the Hindun below the bridge at Ghazeeoodeenuggur, by which means a direct line of water communication would be obtained between the Ganges at Hurdwar and the Jumna. ~~Indeed~~ In the report in which this subject was ~~particularly~~ alluded to, it was remarked that the uses of such a Canal "in the "mere introduction of Timber and "forest produce, would be of infinite "importance, as enabling the "Delhi and other markets to be "supplied direct from the forests "which lie in the vicinity of the "Ganges at its debouche from the

"Mountains"

mountains"

The country is throughout richly cultivated, and the soil of a better description than it was in the Bhoor or Sandy District. Sand however is still an attendant on all excavations exceeding a few feet in depth, and the occurrence of spring water at shallow levels was in some cases a matter of great inconvenience, especially at the Falls and works, where it was considered advisable to lay the foundations at a depth below spring water level. Throughout the whole of the distance however extending from Jullalabad to [illegible] the depth of excavation is sufficient to carry the full canal supply.

At or near the 110th mile and near the village of [illegible] the [illegible] Branch leaves the Canal on its right bank; this branch is intended for the irrigation of the districts [illegible] as well as on the edge of the [illegible], [illegible], [illegible]. It crosses the [illegible] roads [illegible] [illegible] [illegible] [illegible] [illegible] of the village [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] situated [illegible] Canal. [illegible] [illegible] [illegible] [illegible]

Branch

Bhima [illegible] the [illegible] of [illegible] ing's [illegible] adapted to the particular posi-tion in which they are situated, and to the calculated discharge of water necessary for the [illegible] supply, I [illegible] in detail [illegible] in [illegible] Head [illegible] as [illegible] designed, the Regulator over [illegible] at this point has [illegible] of [illegible] feet and that [illegible] Bhima [illegible] waterway of [illegible] feet, divided into one [illegible] of [illegible] feet and [illegible] side [illegible] of 15 feet [illegible] width each.

The [illegible] of [illegible] water [illegible] the [illegible] of the [illegible] is [illegible] the [illegible] in 20 miles [illegible] towards the [illegible] of the [illegible] of the [illegible] [illegible] the [illegible] and the [illegible] 25 [illegible] feet, [illegible] the [illegible] of the [illegible] water.

[illegible] wall[illegible] being ~~[illegible]~~, the [illegible] [illegible] [illegible]

1. Bridge [illegible] the [illegible] [illegible] LII [illegible] [illegible]

2. [illegible] [illegible] [illegible] as [illegible] [illegible] of waterway.

3rd Bridge at Pep[illegible]
3 arches of 45 feet each - 20 ft roadway [illegible] [illegible] [illegible] tops and [illegible] [illegible] [illegible] - and a [illegible] [illegible] attached.

4th Bridge at [illegible], similar to that at Pep[illegible], but without that [illegible] attached.

5th [illegible] [illegible] [illegible] [illegible].

6th Bridge at [illegible], with 3 bays of [illegible] feet each, with [illegible] and [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

7th Bridge at [illegible], similar in [illegible] respect to that at [illegible] with [illegible] [illegible] attached.

8th Bridge at [illegible] of [illegible] description and [illegible] to that at [illegible] with [illegible] [illegible] attached.

[illegible] [illegible] [illegible] had [illegible] [illegible] [illegible] [illegible] built [illegible] [illegible] [illegible] [illegible] [illegible] at the [illegible] and [illegible] [illegible] [illegible] Bridges and [illegible] [illegible] protection was required, [illegible] [illegible] [illegible] [illegible]. The staple material for [illegible] and [illegible] foundations [illegible] [illegible] [illegible] [illegible] from the [illegible] [illegible] downwards, with the [illegible] of bridge arches, have been built almost entirely with [illegible], [illegible] [illegible] procurable from [illegible] in the neighbourhood; the material although variable in compactness and requiring

in the line of communication is undoubtedly [illegible] of more [illegible] capacity; [illegible] greatest [illegible] its [illegible] ordinary [illegible] which enabled the Traveller [illegible] without interruption the whole of the [illegible] at a [illegible] [illegible] [illegible] of Prairie, the [illegible] the [illegible] pastures would [illegible] undoubtedly [illegible] [illegible] the [illegible]. The subject of [illegible] [illegible] [illegible] the [illegible] of the [illegible] being used [illegible] [illegible] [illegible] features of the [illegible] and the ~~production~~ resources of the country.

The [illegible] from the 120th to 140th mile [illegible] Victoria, a [illegible] situated on the [illegible] and at a distance of [illegible] miles on the right of the [illegible], at this [illegible] are but [illegible] miles from the [illegible] at [illegible].

The [illegible] [illegible] [illegible] [illegible] the East [illegible] [illegible] natural features [illegible]

[illegible]

all respects the Ganga as before described, and after a course of [illegible] joins the stream near the Village of Nalduna in the Agra district, at a point just below the Town of Ugran. — The Kali nuddee passes to the East of Sikundra, and to the West of the Town of Khoorja at a distance of 1½ miles, and proceeds onwards by the Towns of Khyr, Russoolpoor, Mudsam and Saidabad to its junction with the ~~great river~~ Jumna.

The Line of Canal therefore, in its passage through this portion of the Bolundshuhur District after crossing the low land [illegible] the banks of the Kali nuddee, is situated between that river and the East Kali nuddee; at their widest points of separation they are only [illegible] miles distant from each other, whilst immediately opposite the Town of Bolundshuhur which is built on the high land overlooking the valley on the eastern side of the East Kali nuddee, the breadth does not exceed 6½ miles. The Canal alignment passes within 1½ miles of the Town of Bolundshuhur, and throughout the whole of the 21 miles which I am now describing runs parallel to, and at a distance of from [illegible] to 12 miles from the East Kali nuddee. In the early part of its course its deviation is in [illegible] of the straight line from the Bolundshuhur Branch head, but at the 127th

and 121st [illegible]

and 131st
miles there are curves of radii of 15414 & 21300 feet, the first tending to bear in a westerly direction and at the 130th mile a curve of the former dimensions to give it a direction towards the East. These curves are adapted to the general direction of the high land and the watershed, as well as to [avoid] running [into] [illegible] connected with sites of houses or villages. The low land which lies at the head of the Lunoon, and which is intersected by the Canal in the vicinity of the 126th mile, has not been considered of sufficient importance to call for addition of [works]. [From] the experience that we have had since the canal has been dug and the [illegible] [illegible] have been [made], there does not appear to be any necessity for them.

The depth of [cutting] in the [illegible] of the country [illegible] the [watershed] [illegible] is 23.5 feet & 14.2 feet [illegible] [illegible] [illegible] it [illegible] from the East Kali Nuddi known as the Kunchen [illegible] East to West. [The country] is highly cultivated throughout although intersected by [illegible] [illegible] ridges in the neighbourhood of [illegible]. The land in [cultivation] is [illegible] good soil, with the exception of those portions of it which are connected with the drainage; the soil below the [surface] is of a light and not very satisfactory description. The depth of excavated channel, however is sufficient for

for the [illegible] water supply, and in this respect is well adapted to the purposes for which it is intended.

[illegible] levels [illegible] the [illegible] that [illegible] under the [illegible] discharge [illegible] the [illegible] that the [illegible] of [illegible] the [illegible] 22·33 feet above the [illegible] of the [illegible] 6 feet above the [illegible] of the [illegible] [illegible] [illegible] the [illegible] at the [illegible] [illegible] that the [illegible] was 24·33 feet, and the River 16·0 feet [illegible] the [illegible] the distance [illegible] these 2 [illegible] equal to 11 miles.

The [illegible] works on this line [illegible] bridges, [illegible] built [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] for [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] bridges, [illegible] [illegible] [illegible] [illegible] provided for [illegible] the [illegible] [illegible] [illegible] [illegible] roads, [illegible] passing [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the

the

the [illegible]

1st Bridge at [illegible] with [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attached.

2nd Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attached.

3rd Bridge at [illegible] 125 feet long [illegible] 3 Bays [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and 1st Class [illegible] attached.

4th Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 130 feet [illegible] [illegible] 3 [illegible] 42 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

5th Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with [illegible] [illegible] attached.

6th Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with a 2nd Class [illegible] attached.

7th Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attached.

[illegible] [illegible] Bridge [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Bridge [illegible] [illegible] [illegible] [illegible]

[illegible] the route [illegible] [illegible] material; [illegible] these points [illegible] used both [illegible] [illegible] [illegible] all lateral length of ballast [illegible] also.— Throughout all this [illegible], [illegible] [illegible] the [illegible] material [illegible] for [illegible].

[illegible] [illegible] usual "wooded" [illegible] [illegible] the [illegible] of the bank, the [illegible] of the track, [illegible] 36 feet [illegible] 15 feet [illegible] this [illegible].

<u>140th to 160th mile</u>

From the 140th to the 160th mile the [illegible] of the Canal [illegible] [illegible], [illegible] the course [illegible] [illegible] [illegible] opposite to the 161st mile [illegible] [illegible] the eastward, regaining its position with regard to the Canal [illegible] [illegible] south. The [illegible] [illegible] [illegible] [illegible] [illegible] altitude of [illegible] [illegible] 11 [illegible] [illegible], the country is [illegible] [illegible] throughout and its [illegible] longitudinally is 2.73 to 1.35 feet per mile. Transversely the slope of the country is from East to West, and [illegible] [illegible] [illegible] [illegible] well [illegible]. Opposite the [illegible] [illegible] [illegible] [illegible]

[illegible]

ridges through which it is ~~passed~~ carried; in other respects the ground is good, although the excavation, [illegible] and a great difference of level shows ~~itself~~ [illegible] by increasing abund-ance along the walls of the canal bed. In this case the channel is somewhat shallower than the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the deepening [illegible] has been made up by embankments of such a nature as to preclude any accident or lead to incon-venience to the country; the earth for this purpose has been procured from the surface on the outside of the canal bound-aries, and [illegible] masonry have been [illegible] [illegible] these boundaries, [illegible] deposits of water.

~~At this point~~ Where the canal runs in the 161st mile, the summit of the boundary is to be put above the end of the [illegible] at 7.333 feet above that [illegible] [illegible] [illegible]

At the 163rd mile, at the village of [illegible] the Telegraph is situated; the [illegible] which the [illegible] is equal to 60 feet [illegible] [illegible] [illegible] is attained [illegible] the [illegible] [illegible] [illegible] [illegible] bridge with its head well protected by masonry [illegible] [illegible] in the steep [illegible] as that most convenient for the purposes of approach to the water. The telegraph is connected ~~[illegible]~~ to the bridge by [illegible] [illegible] [illegible] laid out in the [illegible] [illegible] [illegible] and [illegible] with the different [illegible] and [illegible] in

Russia

[illegible] water course roads, a very complete and very handsome mass of building; the situation is directly opposite and to the East of the Town of Khoorja for the convenience of the population of which these extensive flats were especially constructed. At this point and intermediate between the Escape and the bridge, [illegible] the mass of the building, the site being intended as one of the main Stations on the line of Canal. —

The Escape channel which is excavated to a breadth of 50 [illegible] is cut out into the valley of the East Kali Nuddi, the depression between the Escape falling and the bed of the Kali Nuddi being 11 feet in a distance of 4500 feet [illegible] as was explained in the Escape channel towards the East Kali Nuddi, the arrangements for the passage of the main line of Canal have been designed in connection with a bridge of cross communication and a descent in masonry; further operations with regard to retrogression of levels from the bed of the East Kali Nuddi being postponed until the practical effects of [illegible] can by all occasions have exhibited themselves: in preparation however for this circumstance, material has been collected, so that the means for counteracting the evils will be at a moment's notice avail=able.

=able.—

At the 169th mile the Jaolee Falls where the whole body of the Canal water on a level 8 feet lower than that on which it had been running; this work consists of 5 bays of 20 ft. each giving a clear waterway of 100 feet, the general design of the work being the same as that which has been before described.— The works at the head of the Navigation Channel, locks, mills, Engineer's houses &c. are all built on the same design (vide Atlas Plate XXX)

Three miles below the Jaolee Falls, and close to the 183rd mile Stone, the [illegible] Branch leaves the Canal on the right. The works at the head of this branch are on the same design as those at the Boolundshuhur Branch head before described; the Regulating Bridge across the Canal having a waterway of 120 feet divided into 6 openings of 20 feet each, and that across the head of the Branch having 50 feet waterway with a centre bay of 20 feet, with 2 side bays of 15 feet in width each, the works attached, with the [illegible] dimensions as those before described.—

The capacity of channel for the [illegible] Branch is the same as that of the Boolundshuhur, the head discharge being estimated at 520 cubic feet per second

The

[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] to the position in which it is situated [illegible] [illegible] [illegible] [illegible] drained as far as circumstances will permit, for the [illegible] as [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]; [illegible] lands or flats [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with a good deal of the [illegible] drained [illegible] of the Country; [illegible] [illegible] [illegible] [illegible], the [illegible] on the east and [illegible] [illegible] the west, [illegible] [illegible] all supplies from this neighborhood: [illegible] [illegible], [illegible] [illegible] [illegible] which is [illegible] [illegible] [illegible] with the [illegible] drainage, [illegible] [illegible] a full [illegible] [illegible] [illegible] [illegible] facts [illegible] [illegible] this particular part of the country, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] well [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] has been determined [illegible] [illegible] [illegible] relatively [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] sales.

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the Country [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], its [illegible] [illegible] [illegible] accurately [illegible] [illegible], [illegible] the [illegible] [illegible] of the Country [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Surveys [illegible] [illegible] [illegible] with some [illegible] [illegible] accuracy, as bearing to the East and close by [illegible]

the Town [illegible] a [illegible]

of [illegible] the [illegible]

cultivated district [illegible]

[illegible] Hallaza [illegible]

In describing the [illegible]

and [illegible] ~~[illegible]~~ [illegible]

[illegible]

[illegible]

of [illegible]

[illegible]

[illegible] East [illegible] boundary [illegible]

[illegible]

[illegible]

latest

~~[illegible]~~ [illegible]

and [illegible] eastwards [illegible]

the East, it runs through [illegible]

[illegible]

the District [illegible] Etawa

[illegible]

[illegible]

[illegible]

elected near the Town of

[illegible]

[illegible]

which the two districts [illegible]

[illegible]

[illegible]

[illegible] depth

[illegible]

as [illegible] cut [illegible]

[illegible] and [illegible]

[illegible]

[illegible]

[illegible]

deep and [illegible]

the [illegible] part of the [illegible]

on its approach to the Jumna,

It is [illegible]

[illegible]

the other [illegible] a

boundary [illegible] the tract upon

which the Etawa branch runs,

and

and [illegible] of [illegible] is one [illegible] deserving of attention when considering the design which has been adopted [illegible] out the [illegible] of [illegible].

[illegible] works [illegible] [illegible] the [illegible] downwards [illegible] follows:

1st [illegible] [illegible] of 3 [illegible] of [illegible] [illegible] heads [illegible] [illegible] with [illegible] [illegible] [illegible] [illegible] Plate XXXVIII

2nd [illegible] with a water way of 3 [illegible] of [illegible] feet [illegible] with [illegible] heads [illegible] [illegible] with [illegible] [illegible].

3rd [illegible] works, the [illegible] water way of 100 feet [illegible] 3 bays of [illegible] [illegible] heads [illegible] [illegible] [illegible] [illegible] (see Plate XL)

4th [illegible] [illegible] head works [illegible] of the [illegible] [illegible] head [illegible] water way of [illegible] [illegible] [illegible] [illegible] Regulator [illegible] [illegible] [illegible] attached.

5th Bridge at [illegible] with a water way of 3 bays of 40 feet [illegible] [illegible] heads [illegible] [illegible] attached.

[illegible]

6th Bridge at [illegible], [illegible] [illegible] 31st [illegible], [illegible] [illegible] [illegible].

7th Bridge at [illegible], [illegible] [illegible] [illegible], [illegible] [illegible] attained.

[illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water in [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] feet [illegible] [illegible] [illegible] [illegible] feet.

On [illegible] [illegible] the 161st [illegible] [illegible] 150th [illegible] the [illegible] [illegible] [illegible] to the [illegible] end of the [illegible] of [illegible] at which the [illegible] by a radius of 20000 feet [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] of the road [illegible] of the [illegible] [illegible] [illegible] [illegible], and of the [illegible] of [illegible] and [illegible] [illegible] [illegible] these [illegible] [illegible] [illegible]; at this point [illegible] [illegible] [illegible] 5 miles [illegible] the [illegible] [illegible] [illegible] [illegible] at [illegible], the [illegible] [illegible] of the [illegible] [illegible] [illegible]; the [illegible] is marked by a [illegible] [illegible] [illegible] [illegible] (Pinus [illegible]) the first of the [illegible] that [illegible] [illegible] in the [illegible] and with the exception of a few plants [illegible] [illegible] in the [illegible] [illegible] in the [illegible] between [illegible] [illegible] [illegible] almost the first [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] in [illegible] [illegible] latitudes.

The [illegible] longitudinally of the [illegible] [illegible] [illegible] country from the 161st mile is 26.[illegible] feet

[illegible]

giving an average fall per mile of 13½ feet, its transverse slope tends towards the Thames, from the East Ridge under the Harrow and ultimately, as the canal proceeds onwards, to the banks of the Serpentine. The canal [illegible] kept as high as possible [illegible] so that it may avoid the contracts in which [illegible] and [illegible] the [illegible] of [illegible] the canal which passes between that Town and the East [illegible], approaches to within 1¾ miles of the [illegible] of this close approximation to the above River, the depth of the excavation is in a considerable degree sufficient for the required water supply; embankments have been made to [illegible] the requisite height [illegible] from the outside of the boundaries, ~~and the measures that have been taken~~ the consolidation ~~these thick embankments~~ of which, together with the magnitude of their proportions, will secure the country from any liability to accident, ~~[illegible]~~ the measures which have been taken to secure efficient drainage also, it is hoped, relieve the neighbourhood from ~~[illegible]~~ inundation. There was so much earth required for these lines of Embankment that the usual method of taking a superficial foot in depth over large areas was utterly impracticable, from the distance to which earth would have

have to be carried; & they would deter-mine on the excavation of a series of ponds at fixed distances from the canal boundaries, as well as from each other, of dimen-sions by diameters & depths adap-ted to the [illegible] content of each region of the canal line; it struck me that in practice, [illegible] a deep trench or reservoir might hereafter be of great use in catch-ing supplies of drainage water, and of adding the lands to be irrigated of the [illegible] to the right [illegible]; the depth to which these reservoirs are dug will pre-vent the accumulation of [illegible] weeds and the rank vegetation that usually attends shallow pools. At any rate the necessity (should the speculations on their use as reservoirs for irrigation hereafter be [illegible]) of keeping them clean and free from [illegible] appendages may be considered a duty of the [illegible] upon the supervision of the [illegible].

The breadth of canal [illegible] between the 1st [illegible] and the [illegible] [illegible] mile of the course of the canal is [illegible] feet, and [illegible] was, [illegible] the breadth to be [illegible] feet [illegible] at Nadoun; [illegible], however, the [illegible] of the [illegible] that at the point of its course [illegible] at a well defined section, reduces the width to 11 feet [illegible] the Canal [illegible] immediately, the width being

[illegible] situated exactly on the [illegible] midway between the two rivers.

At the point where the Canal passes the crown of the dividing ridge [illegible] the country, it is [illegible] feet above the [illegible] of the [illegible], and 15.84 feet above that of the [illegible], at points [illegible] to the [illegible].

[illegible] the [illegible] [illegible] cultivation, [illegible] immediate [illegible] walls of the [illegible] great deal of [illegible], the [illegible] depth of water, [illegible] being [illegible] 10 feet

Near the village of Simra, and at the 163rd mile of the course of the Canal, the water is suddenly [illegible] which [illegible] described at [illegible]; [illegible] as [illegible] of the [illegible] equal to 5 feet in perpendicular height, and it [illegible] head of the Country, with ~~[illegible]~~ [illegible] approach to the heads of the [illegible] and [illegible] flow towards the [illegible] to the Jumna, and to the [illegible] passes off to the [illegible]. The navigable cut with its arrangements for the departure of vessels from the main line, of locks, [illegible], and [illegible]

Heads are precisely similar in de-
sign to those figured in the Atlas
Plate XXX

Near the village of Kasimpur
which is situated about 2 miles
below the Jumna Falls, the Escape
No 5, into the East Kali Nuddi,
similar in all respects to that at
Moonda [illegible], might [illegible] however
divided into [illegible] of 6 feet
each, it [illegible] with the
Bridge, and [illegible] design, and
with [illegible] of
21 feet in width, precisely as has been
described at the Moonda [illegible]
the distance [illegible] at the
Kasimpur Escape and the East
Kali Nuddi is 20577 feet and the
total fall between the Escape [illegible]
and the bed of the [illegible] is 121.35 feet
The plan which has been
described for [illegible] the diffi-
culties of [illegible]
of these Escapes [illegible]
practice at the [illegible] works;
and the method of passing the
[illegible] across the Escape
Channel [illegible] in every respect
similar to that which has been
adopted before.

The Moddee [illegible] Canal
and [illegible] ~~[illegible]~~ Terminal lines are in
design [illegible] of the [illegible]
Heads [illegible] described; the main
Trunk Channel [illegible] opposite
to the Heads, [illegible] in a
line which [illegible] divide
into two equal parts the angle of
departure of the two branches.
This angle is equal to 43 degrees
and the main [illegible] meets it on
an angle of 158½ degrees – The
design

design of this particular line [illegible] out in the works is, that the [illegible] [illegible] of the Main line shall meet the demands of the [illegible] left under provision of the [illegible] circumstances, so that as [illegible] as direction are concerned the supply to each [illegible] is provided. This [illegible] [illegible] maintained by the [illegible] Bridges over the road in each [illegible] of the same dimensions, [illegible] 100 [illegible] [illegible] 5 bays [illegible] supply of each [illegible] [illegible] [illegible] [illegible] [illegible] the medium of the [illegible] apparatus; [illegible] [illegible], one [illegible] [illegible] [illegible] [illegible] raised [illegible] [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] Walls. The [illegible] great importance, and as a [illegible] general point, has [illegible] attached to it.

The works at this station, opposite the Bridge of [illegible], [illegible] may be thus enumerated.

1st [illegible] [illegible] to [illegible] Atlas (plate XL)

2nd [illegible] works, consisting of

of a Bridge of 2 bays of 46 feet each in Waterway, Regulator and Inlet heads, Ghats and Escape [illegible] the Eastern [illegible], with a 1st class Chouki attached.

3rd Bridge at [illegible] with a waterway of 3 bays of 46 feet each, with Regulator and Inlet heads, Ghats, and a 2nd class Chouki attached.

4th Bridge at [illegible] similar to that at [illegible] with a 2nd class Chouki attached

5th Bridge at [illegible] similar to that at [illegible] with a 2nd class Chouki attached

6th Bridge at [illegible] similar to that at [illegible], with a 2nd class Chouki attached.

7th [illegible] Regulators [illegible] [illegible] at the heads of [illegible] [illegible], but with the [illegible] bridges [illegible] a waterway of 100 feet [illegible] divided into 5 bays of 20 feet each — a 1st class Chouki being attached to the works.

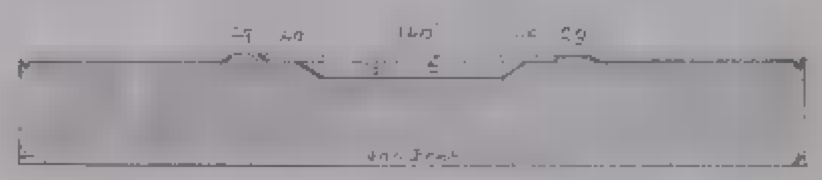
As regards the works throughout the [illegible] District the staple material for building has been kunkur, the use of bricks being confined to [illegible] [illegible] kunkur was [illegible] procurable.

The works at [illegible] which are situated at the down stream extremity of the main Canal ~~[illegible]~~, and the terminal point of the section included between

between the entrance upon the high land at Cookes, and the Fork at which the [illegible] Branches separate. [illegible] are given in [illegible] detail as [illegible] des- [illegible] the profile and [illegible] the Canal [illegible] will be [illegible] from this detail that the [illegible] been [illegible] subordinate [illegible] means [illegible] length [illegible] from [illegible] the Main [illegible] the west, and that the extraordinary de- [illegible] takes place [illegible] the most efficient [illegible] lands [illegible] situated at [illegible] distances from the main channel, [illegible] lands being [illegible] distance.

The capacity of the channel [illegible] the head of the Outfall [illegible] of the course of the main Canal has not been increased from the dimensions laid down [illegible] being as follows,

Fig. XX. [illegible] Section [illegible]



That is to say the height and [illegible]

the [illegible]

top of the bank from the Canal bed is 15 feet, and that of the berm from the Canal bed is 12 feet; the latter is a constant quantity, and although it is exceeded in many places where the depth of [illegible] is any [illegible], the depth is 12 feet for the important portion which is intended for the retention of the canal water is always maintained; the height and breadth of the embankments vary with the amount of earth excavated from the Canal, but the canal is always of [illegible], so as to [illegible], and it is only at a few parts of the Canal, [illegible] instances [illegible] the depressions of the [illegible] of the country [illegible] shallow [illegible], and consequently [illegible] to make [illegible] [illegible] that [illegible] [illegible] [illegible].

The breadth of [illegible] the Canal and its berms, however is [illegible] from 150 to 200 feet, and the latter [illegible] [illegible] [illegible] breadth which was [illegible] into the [illegible] from 150 to 166 feet. The Canal Channel may be considered as [illegible] as its bed is [illegible] to the [illegible] [illegible], and a [illegible] [illegible] of slope [illegible] sides, allowing for a gradual extension in breadth to the entire channel may be anticipated.

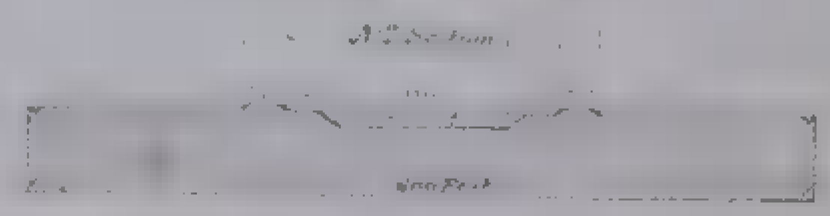
It will be observed by referring

to

in Diagram XVII. page 65. that the estimated maximum discharge at Roorkee is equal to 6750 cubic feet per second, and that this supply, by the abstraction of 330 cubic feet per second for the [illegible] heads at the [illegible] Muzuffernuggur, [illegible] South [illegible] [illegible] cubic feet per second [illegible] allowed, and of [illegible] cubic feet per second for the supply of the Futtehgurh [illegible]; [illegible] at the head of the [illegible] Regulator at that point to [illegible] cubic feet per second.

The Regulator across the Main Canal at the Futtehgurh Branch Head has, as has been before stated, a water-way of 150 feet in 9 bays of [illegible] feet each. From the Futtehgurh Branch head, the section of the Canal is reduced to the following dimensions:

Diag. XXI.



and this ~~dimension~~ is continued ~~[illegible]~~ [illegible] to the [illegible], or ~~[illegible]~~ [illegible] Escape into the [illegible] [illegible], [illegible] [illegible] of [illegible] [illegible] [illegible] in width to 12 feet [illegible] it was ~~[illegible]~~ in the [illegible] of [illegible]. [illegible] [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], that [illegible] all the dimensions [illegible] [illegible] [illegible] [illegible] reduced below the figures above [illegible], and the

[illegible]

three dimensions of 130-40-40, or the breadth of the rectangle, and the distances between that rectangle and the feet of the embankment slopes ~~[illegible]~~ [illegible] in all cases a constant quantity. In this term the width of bridges and tubes [illegible] situated at the larger dimensions above specified, and bridges with side passages [illegible] the flanks, and in prolongation of the towing path, they [illegible] have [illegible] for the convenience of traffic, as well as of ~~[illegible]~~ [illegible] of the bridge keepers.

Along the [illegible] Escaut [illegible] the [illegible] mile, the section of the canal is [illegible] within the [illegible] that area [illegible] the width of water are ~~[illegible]~~ [illegible] reduced from 161 to 151 feet; from [illegible] to the 11th mile, or to the head of the [illegible] Bassin, the width of water-way is slightly reduced to 111 feet, the [illegible] [illegible] the [illegible] the [illegible] of [illegible] [illegible] [illegible] less than 11 [illegible]. The tunnel [illegible] the ~~[illegible]~~ [illegible] Souvatre, has [illegible] supply equal to 4331 cubic feet [illegible]; the whole volume of [illegible] that [illegible] the [illegible] being equal to 300 cubic feet. [illegible] the supply of the [illegible] 220 cubic feet [illegible] the 130 [illegible] [illegible] remark that [illegible] to this point

point, or to the head of the Bolundshuhur Branch, the water for the purposes of irrigation is taken from heads situated immediately above the masonry Falls; of these Falls eight are on the right and eight are on the left of the Canal; the supply of water allowed for these 16 Falls is equal to that calculated [illegible] for 82½ miles at 5 Cubic feet per mile, the upper 27½ miles [illegible] supply from down-wards. [illegible] [illegible] 13:- each of these 16 heads, therefore, has a supply [illegible] equal to 26½ Cubic feet, allowing [illegible] the Canal under the most advantageous [illegible] circumstances [illegible] and [illegible] facility for drawing a regular supply. I consider that the means are so ample [illegible] for extending irrigation that there will be nothing to prevent the passage of the West [illegible] and the introduction of water courses on the surface of the country [illegible] the [illegible]: the Bridges and ramps of approach to the bridges on the West Kali Nuddi may be the means of facilitating this object, but [illegible] that Aqueducts built spe-cifically for the purpose, would lead to returns sufficiently remu-nerative. The station of Sufroor and the Khud lands which are separated from the line of Canal by the Cheeya Nuddi will be reached

reached with probably greater facility by turning the roads [illegible] the Rudas itself, but I believe that there is no [illegible] on the whole [illegible], with the [illegible] of the canal boundary lines [illegible], that would be [illegible] objection [illegible] the [illegible] impediment to the passage of a [illegible] both [illegible] depth [illegible] [illegible], is [illegible] advantage [illegible] [illegible] and [illegible] it is absolutely necessary to provide a free passage, so that [illegible] that [illegible] of [illegible], [illegible] [illegible], it is [illegible] [illegible] to [illegible]

anxiety [illegible] those shallow [illegible] [illegible] superior [illegible] with the [illegible] attended [illegible]

The water way of the Bridges continue of the dimensions above specified as far south as [illegible], below which it is diminished to 150 feet in 3 [illegible] of [illegible] each below the [illegible] Falls the water way is again reduced to 130 feet in [illegible] water ways of 40 feet each. Towards the [illegible] of supply and the diminished capacity required, the [illegible] downwards are reduced to 130 feet in width of waterway.

The waterway of the Regulator on the canal which is situated at and immediately below the Bo[illegible] Head is as I have before mentioned equal to 150 feet in width

in

in 5 Openings of 9 feet each; the advantages of giving sufficient waterway in manageable openings at these Regulators are great, as it relieves the Channel from the wear and tear which would otherwise attend upon the working of the shutters under a restricted opening.

From the 110th to the 1[illegible]th mile the capacity of the Channel of the Canal is [illegible] width ~~continued [illegible]~~ as described [illegible] the 163rd mile downwards, the difference between the [illegible] and bed levels being reduced from 11 to 10 feet, it having been arranged in this part of the course of the Canal to reduce the maximum depth of the water to 8 feet; the section on this line is thus, →

Fig. XXII

Cross Section

From the 144th mile opposite the [illegible] side of the Jumna [illegible] to the 181st mile, or to the Nanoon Regulator at the end of the main line of Canal, the width of the Channel is gradually diminished to 80 feet, or a reduction [illegible] per mile; the depth of trapezoidal Channel being maintained in all cases at 10 feet, so that there may be a clear 2 feet above the high water mark.

At the Koel Branch Head the width of the Canal Channel is represented by the following section:

Fig. XXIII

the discharge at this point being equal to 3530 cubic feet per second the Chenab over the Canal having a waterway of 120 feet in width in 6 openings of 20 feet each.

On the Channel reaching Nanon, and immediately above the separation of the two branches the capacity is shown by the following section:

Plate XXIV

the theoretical discharge on the arrival of the water at that place being equal to 3531 cubic feet per second.

I may remark that from the 116th mile downwards the regularity of the berm at a height of 11 feet above the Canal bed has been maintained with great uniformity; the reason why the same regularity was not carried out in the Channel above this point was from the extraordinary ~~[illegible]~~ depth of digging at parts where the Channel came in contact with the Bhour land and the sand hills, and the ~~consequent~~ great expense that would in consequence have attended a reduction of the berm to one uniform level; at this period of our operations and with so much experience to guide us, I am not sure that it would not have been better, as it certainly would have ~~added~~ ~~to the~~ improved ~~much to~~ the look of the work   R, 24.1.xii

work, had the berms been constructed on a level parallel with that of the Canal bed; in all cases however they have been sloped off on long lines so as to render the irregularities as little apparent as possible, and in no case have they been made less in height than that designed, and as shewn in the minimum sections figured in the above diagrams.—

The width of waterway of the bridges from the 110th to the 180th Mile has been maintained on two uniform dimensions, viz. of 135 and 120 feet, the former having 3 bays of 45 feet each, and the latter 3 bays of 40 feet each. My object in keeping to these two sizes was to give the greatest possible relief to the water in its passage through the bridges, and to simplify the construction, by which both time and expenditure were saved; the design of these bridges is the same as those before described with Towing path arches in prolongation of the towing path of the Berm (vide Atlas Plate)*

With the exception of the Lumkoura and Uchubja Bridges, where the application of Outlets for irrigation did not appear to be desirable every bridge from the Bolundshuhur head downwards, has 2 Rajbuha heads attached to it, one on each side of the Canal (vide Atlas Plate)

The Channels of these heads are made ten feet wide, for the purpose of giving full depth of water to the

Depth

* [illegible] Falls [illegible] a bay of 100 feet in breadth [illegible] that the water [illegible] passes over [illegible]

escape of water, or for the fixing of Modules or other apparatus that may be at any time designed for the purpose of regulating the discharge: the width and height of these Openings as they have been now built will, I hope, place it ~~out of the region of~~ beyond possibility that they can require enlargement, which would of course involve a pulling down and reconstruction of the Channel; a reduction to the size of the present waterway can be easily managed by building up and diminishing the size of the Opening. In every case, however, the sill or flooring of the Rajbuha Channel is laid 2 feet above the bed of the Canal and of the flooring of the Bridge ~~floor nearest~~ to which it is attached; the object of this arrangement being to secure the passage of ~~an advanced movement~~ ~~to~~ at least 24 inches in depth of the Canal supply, and by these means to give water to the country ~~beyond~~ in advance ~~the lower districts~~, which had the Zumeendars in the upper ~~ones~~ districts the power to drain off the Canal to its bed, would in case of drought and when the competition was great have in all probability no water at all. This point it will be observed has been particularly attended to in the Irrigation outlets above the heads of the tails; the Assofnuggur and Jusna, which are the two extremes and have to maintain a supply for a long line of country have their sills constructed on a level with the Canal bed, by which

every

every advantage will be gained in the supply of the Rajbuha-lines, whereas those which lie intermediately have their sills raised on a higher level, i.e. 1 foot above the bed of the Canal, so that water equal in amount to that depth may pass onwards for the irrigation of the districts ~~lying in the lower regions~~

I dont consider that the close proximity of the East Kalli Nuddi on the left of the Canal is to act in the smallest degree as a limit to the extent of irrigation from the Rajbuhas or heads lying on that side, — by the use of masonry [illegible] and open [illegible] Channels stretched across them, the river can be passed without any difficulty, and the valley itself is easily overcome by an earthen embankment; the latter would in no instance exceed in dimensions some of the raised Channels which have been built in connection with the Rajbuhas on the Eastern Jumna Canal; that at [illegible], for instance, which is upwards of [illegible] mile in length, and with the bed of the watercourse raised 18 feet above the level of the valley. The East Kalli Nuddi will therefore be no impediment to the Irrigation of the Country lying on its left bank. —

~~The capacities of the different Sections of the Canal Channels as described above are as follows.~~ the values of R and b are calculated

[illegible] theoretical depth of [illegible] in the Different sections of the Canal [illegible] as figured in the above Diagram the [illegible] as follows; the actual capacity of the channel ~~being~~ (from the circumstance of its being 2 feet deeper than that of mean high water) being capable of carrying a larger body of water than that theoretically [illegible] to it.

culated on even numbers, ·5 being the limit in the case, and even hundreds in the other. —

ectn						
No: 1						
2						
5						
[illegible]						
5						

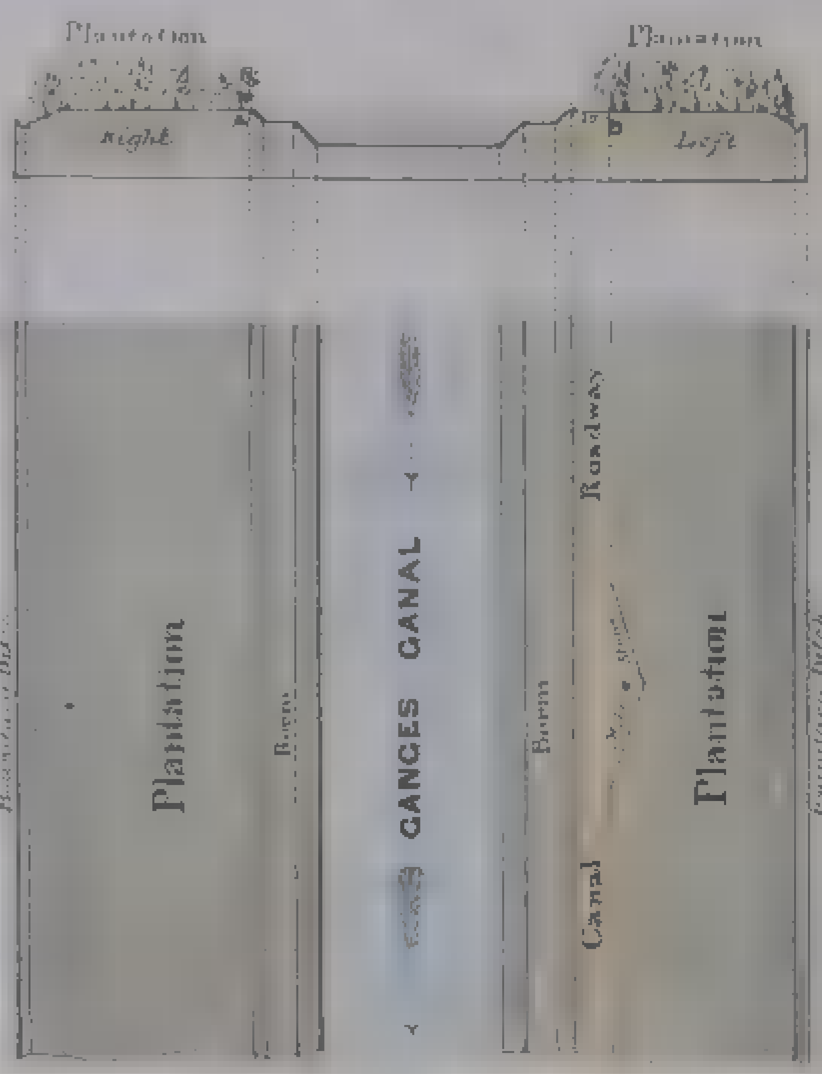
It will be understood from the method of disposing of the earth which is excavated from the Canal Channel that the breadth of the esplanade on the top of the Embankments, where these Embankments exceed in width 20 feet, depends entirely on the Cubic Content of the Excavated Channel. With the exception of detached portions equal in total length to nine miles, the whole of the banks from Roorkee to the 18th mile at Nanoo are much in excess to the minimum dimensions, they frequently occupy the whole space between the berms and the Canal boundaries, and in this case offer a fine open esplanade for the purposes of roadway.

The maintenance of a line of roadway both for convenience of communication and for the purposes of patrol, is a point that has been anxiously looked to; this road is in some measure connected with the plantations, which are intended to occupy all the space Space between the Canal boundaries

-aries that is not required for other purposes. The general design and object of these plantations whether for forest or for fruit trees is explained in the Volume of Tables.

The following plan and section exhibit the lining out of the road, at a point where it comes in contact with a Mile Stone; these Stones are numbered from the Myapoor Regulating Bridge in a continued series to the end of the main Canal at Cawnpore, they, as it will be observed situated away from the road, on a platform kept clear for this especial purpose; they consist of a square prism of Stone embedded in a Cylindrical Mass of masonry, the top of which acts as a bench mark, and the figures engraved on the stone independently of the mileage, gives the exact depression of that particular point from the flooring of the Regulating Bridge at Myapoor

Diagram XXV



On the above diagram the width of the Bank is supposed to be much greater than that laid down as a minimum dimension, in fact as it really is in the greater part of this section of the line; the road is [illegible] 20 feet wide with an additional 10 feet between it and the plantations, so as to prevent the passage being interrupted ~~with~~ by boughs of trees; the road by these means actually maintains a width of 30 feet, it has a slight slope externally so that all drainage may flow away from, instead of towards the Canal channel, and there is a low edging of earth carried along the crest of the interior slope for the purpose of preventing the action of the water from destroying its uniformity.

The above rule applies equally to banks of minimum dimension, the plantations being limited to a line B drawn in rear and on the [illegible] bund at the distance of 30 feet from the crest of the interior slope. Platforms of earth connected with and equal in height with the embankment are in this case used for the accommodation of the [illegible] should such be sufficient to occur on these narrow [illegible] of roadway. In the sandy tracts the [illegible] ~~[illegible]~~ will require some species of metalling, but in other parts the plain soil will ~~[illegible]~~ be sufficient [illegible] sufficient durability to admit of its being kept in order. This

road

road is situated on the left or East side of the canal where the division line passes [illegible] [illegible] reservoirs, the plantations are made to the roadway on the [illegible] and [illegible] part of the [illegible]: the road is specifically for the Canal Establishment and for [illegible] purposes and is not [illegible] as a [illegible] communication.

The following [illegible] in Diagram XXV will [illegible] to [illegible] the plantations are carried, and the [illegible] of [illegible] [illegible] and other nuisances that might impede the flow of the water, [illegible] AB designate the [illegible] in the vicinity of the stream that it is proposed to keep [illegible] within this [illegible] are to be allowed [illegible], [illegible] the [illegible] space up to the Canal boundaries is devoted to Plantations of [illegible] trees. It may [illegible] that with a desire to secure good shade to the roadway I have [illegible] a line of [illegible] trees [illegible] marked B throughout the whole length of the canal. These trees are planted at 100 feet apart, and when they have taken [illegible] [illegible] progress of [illegible] [illegible] [illegible] whole line of the same [illegible] quality, there is some difficulty ~~attending~~ the [illegible] [illegible] as [illegible] the [illegible], we attach [illegible]; it requires [illegible] attention

in

in this cool weather during the dry weather, and it is [illegible] [illegible] should be made to [illegible] [illegible] in its season. In these cases I am satisfied the [illegible] to [illegible] adequate protection, so that the gardeners who are in charge of the [illegible] plantations may not be burdened with their duties in securing the growth of this benefaction, the advantage of having 20 or 30 [illegible] [illegible], will be duly appreciated by those who have to travel along the Grand Trunk Road. It must not be understood that the mango trees above reported are grafts, they are the common country mango, which grows to its natural size, both in breadth and width in its state of [illegible] nature. The plantations of "grafted mangoes" are only [illegible] [illegible] [illegible], ~~[illegible]~~ situated near the 1st class bungalows, or [illegible] [illegible] points of the different districts which are on an average (with the exception of those built for special purposes at falls and other large works) ~~throughout the whole [illegible] of the Road~~ about 12 miles apart from each other.

The works on this section were divided into two portions, which have been carried on under the titles of the 2nd and 3rd divisions. The 2nd, commencing at a point below the Assoignieggen, [illegible] [illegible] [illegible] the works as I have before described are included in the [illegible] Division, and terminating at the 10th mile on

at

at the departure of the Bolundshuhur branch, was commenced under the executive management of Captain A. J. Turnbull of the Engineers who in December 18[illegible] was relieved by Lieutenant E. Fraser of the same corps; on Lieut. Fraser's departure on medical certificate to England in October 1850, Mr Frederick Read the senior Assistant in the Division assumed charge of the works, and under this Gentleman's management, the Division has been brought to its present state of completion. The Futtehgurh branch, the works of which have not yet been begun, is included in the 2nd Division.

The 3rd Division is that from the 110th to the 1[illegible] mile, including the terminal works at each extremity, have been begun and completed under the supervision and management of Mr Philip Volk. Both the Bolundshuhur and Koel Branches are included in the 3rd Division.

~~CHAPTER IX~~

~~[illegible]~~

III "The Country from Nanoo to the "Ganges and Jumna Rivers, "marked by a deficiency of fall "in the surface of the country "and by its connection with the "Rinde, Seyngoor, Pandoo, "and other Rivers which drain "the flat lands of the Central "Districts."

This section includes both the Cawnpore and Etawah or Terminal lines Branches into

into which the main trunk is sepa-
rated at the Nanoo Locks: it
naturally, therefore, comes under
two heads, and as the line which
runs between the Eesun and Rinde
is that of my original survey,
and that which was explained
in my report of 1845 I shall in
~~entering into~~ discussing a detail ~~of~~ the country
below the Nanoo ~~[illegible]~~ first to
allude to the line from a Easterly
Branch ~~and~~ being that which is the
connecting link between the
Canal head and the Ganges River.
After prefatory remarks, however
regarding the site taken up for
the head of these Branches, and
the ~~[illegible]~~ reasons for selecting the Nanoo
~~for this particular site~~ will ren-
-der the details which follow
much more distinct and inter-
-esting.—

I have already referred to the
Sengoor and Rinde drainage
as having influenced in a great
measure the direction upon which
the main line is carried from
the 15th mile, or from the neigh-
-bourhood of the town of Somna
[illegible]; this drainage shows
itself in a very undecided and
unmarked character, along a line
of country passing Koel, Allygurh,
Nanoo, Akrabad, and then to
a point as far as the town of
Sikundra Rao; the direction of
this drainage [illegible] from the
East Kalli Nuddi, towards the
right of the canal line; in the
neighbourhood of Sikundra Rao,
however, another series of jheels

or

an extensive flats occur, and from thence rises the Eesun river a line of drainage which keeps to the left of the Canal; in procuring therefore, a point for the head of the Branches it was necessary, in such a labyrinth of watersheds, to look to that which would give the greatest facilities in turning the heads of the different rivers, for passing between those of the Rinde & Sengur with the least possible interference with the natural drainage; and by reaching Khundeo Rao and the country lying to the East of it between the Eesun and Rinde with as little interruption as possible to the cross drainage existing between Akrabad and Khundeo Rao. The difficulties of this ground will be more clearly understood by a reference to the map (Atlas plate V); the whole surface was carefully examined, and the site at Nanoon, a village situated 2 miles to the west of the town of Akrabad, was determined on as that most convenient for the required purposes; it enabled us to reach the high land stretching between the Eesun and Rinde along which the Cawnpoor Branch is directed with moderate interference from country drainage, and it placed the Etawah Branch on the ridge between the Rinde and Sengur without any interference with the watershed at all. I believe that the position fixed upon at Nanoon for the head

Head works of the ~~[illegible]~~ Terminal lines, is the Centre, and that by establishing the falls at that particular point we have, by the least amount of artificial aid, left nature to carry out the operations required. The design for the slopes of the bed of these branches is in both cases precisely the same; in the early part of their course, the slope of 15 inches has been retained as far as the natural profile would admit of it, and when this ceases to be the case, the slopes are reduced to 12 inches per mile, the surplus fall being overcome by masonry descents and rapids; the detail of this part of the work will be fully entered upon hereafter. For the reasons above specified I shall commence the detail of the works below, and, by taking up those between the [illegible] and the [illegible] terminating in the Ganges river; this ~~line~~ [illegible] of works is denominated

The Cawnpore ~~[illegible]~~ Terminal line

The total length of this Canal from the [illegible] Regulator to the terminus on the Ganges at Cawnpore is 169 miles 3700 ft. After leaving Roorkee, and after having overcome the difficulties of the falls, which follow between that place and [illegible] Rao, the Canal proceeds in an easterly direction, keeping to the line of the [illegible] original survey, and maintaining

an

an almost direct south [illegible] naturally [illegible] the [illegible] and [illegible] River as far as the 75th [illegible] of the village [illegible] from this point the [illegible] [illegible] [illegible] parallel [illegible] with the [illegible] proceeds towards [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible], the [illegible] [illegible] [illegible] on the [illegible] [illegible] slides and [illegible] [illegible] [illegible] villages situated [illegible] the [illegible] [illegible]) takes up the [illegible] [illegible] the [illegible] [illegible] and [illegible] on a [illegible] parallel [illegible] the [illegible]. At the 9th [illegible], [illegible] the [illegible] [illegible] leaves the [illegible] of the Pandoo [illegible] proceeds [illegible] as [illegible] [illegible] [illegible], [illegible] [illegible] the [illegible] [illegible] reaches the [illegible] mile, [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] and the [illegible] [illegible] Campoor and Bailore, [illegible], [illegible] this [illegible] [illegible] with the river on the left, and the Pandoo [illegible] maintaining its parallel [illegible] with the [illegible] proceeds onwards to the village of Ba[illegible] to the 160th mile, from thence it takes a long sweep to the north east, and passing between the Town and [illegible] Bazars of [illegible]poor, enters the [illegible] River by a series of [illegible] and falls.

The above [illegible] outline will convey a [illegible] [illegible] of the position which the [illegible] occupies, with [illegible] to the [illegible], [illegible], Pandoo and [illegible]

Ruins: I shall now take up the details of the system which I have upon the map, & describing the localities and the several [illegible] which they pass in specific distances of the course of the canal; by this plan, commencing at [illegible] I shall take the first thirty miles ~~which~~ where [illegible] road ~~[illegible]~~ between the towns of [illegible], and the villages of [illegible] and [illegible] ~~[illegible]~~ [illegible] the canal ~~passes~~.-

With the exception of a slight curve which gives the canal a direction to the south of the true [illegible], the [illegible] throughout the whole of the 34 mile portion [illegible] is at [illegible] due south east. [illegible] near the [illegible], and [illegible], and [illegible] its arrival at [illegible], the [illegible] canal crosses the country, [illegible] with the roads [illegible], but at the 11th mile ~~[illegible]~~ near the village of [illegible], [illegible] the most distinct and traceable [illegible] of [illegible] which lie on the [illegible] of [illegible], [illegible] the [illegible] appears to pass round on the north of [illegible], [illegible] to the [illegible] village of [illegible], it then crosses the [illegible] canal and sweeping round the village of [illegible], [illegible] course assumes under that shape the name of the "[illegible]undee". The true [illegible] may be considered as that above described, originating [illegible] 1st 30th mile

north

north of Nanoon, the line of drainage appears to be the most connected of the series, its indistinctness, however, requiring, by actual instrumental levelling, [illegible] to be understood up to [illegible] [illegible], the maximum depth of the main course [illegible] [illegible] Nanoon is [illegible] 2 feet below the surface of the [illegible] [illegible] round [illegible] and [illegible] [illegible] it was not [illegible] 12 feet in depth. At the 6th mile and near the villages of Gopie and Sudain the hollow is of the same character in its immediate junction with the Canal, and the drainage appears to pass off towards the [illegible] without any perceptible depression. At the 6th mile the hollow bears some resemblance to that described as crossing the Canal at the 4th mile, but it is less extensive, although evidently connected with a quantity of [illegible] ground near the high village of [illegible] on the left of the Canal and under which the water passes off to the lands. The following diagram gives a representation of the drainage above mentioned.

Diag: XXVI

In carrying the Canal ~~over~~ the above 9 miles of its course therefore, we have crossed three defined points over which the drainage towards the Pandu River naturally runs; on this length of Canal there are three Bridges situated at Keshupur, Rudain and Ginnowli, each of which is provided with masonry Inlets; these Bridge Inlets however were constructed more with a view to prevent the accumulation of water ~~wanted~~ by the interference of the Bridge approaches with the drainage of the Country, than to relieve the drainage of the Country itself, my object in all cases having been to turn rain water away from the Canal into the Rivers lying on the right or left, so that the Canal line may be perfectly free and dry. Unassisted the Inlets at the Bridges therefore would give little relief to the Country lying on the left, which had thus been cut off from its natural means of drainage. To obviate the difficulties of our position in this neighbourhood, an escape Channel has been excavated from a point above the Ginnowli Bridge, or that which is situated on the lowest levels, to the East Kalli Nuddi: and cuts have been made connecting the different hollows in the 4th 6th and 9th Miles with the Escape Channel: the drainage therefore will pass down, parallel to, and on the left of the Canal,

and

and find an Escape in the
Channel above described. The
distance from the Canal at
Ginnowli to the East Kalli Nud-
-di is 11 Miles and the Escape
Channel joins a Ravine near
the village of Chowra lying on
the Right bank of that River,
the difference of level between the
sill of the Escape at Ginnowli
and the ~~[illegible]~~ bed of the East Kalli
Nuddi is "8·67 feet or 2·42' per Mile
the Excavation has from motives
of Economy only been carried to
a width of 10 feet as the wear and
tear of the Current will, it is
supposed, widen it sufficiently
for all practical purposes. Ad-
vantage has been taken of the
necessity which arose for Excava-
-ting the Channel and for Connect-
-ing the drainage with the East
Kalli Nuddi, to build an Escape
Head from the Canal Channel
with 18 feet waterway immediately
above the Ginnowli Bridge; we
have therefore the means during
the whole year, of using this Es-
-cape Channel for Canal purposes
as well as for those of Country
drainage. As the Channel in
question crosses the Trunk Mail
Road, the bridge required for
the purposes of this Road has
been built with a waterway
of 30 feet in width, so that there
may be ample space for the
passage of the water, and also ~~am-~~
~~-ple space~~ for any increased
width to the present Excavated
line, which may ~~be detrimen~~ [illegible]
~~-tal~~ the passage of flood water.
The advantages are by no means
a

a small one, established a Canal outlet in connection with this Drainage is that, if such should be necessary, an occasional scour can be given by passing a current of Canal water down it.

From Giminowli the Canal passes onwards on the same bearing, leaving the Town of Chandra Rao on its left at the distance of a mile; in the neighborhood of this town, encircling it in fact, are numerous shallow depressions, in which the Esun River which henceforward becomes our left boundary, has its origin; these depressions, with a profile of country very irregular (and as I have described elsewhere when pointing out the peculiarities of these Doab Rivers so marvellously unobservable from their shallowness that the irregularities are only to be traced by the levelling Instrument) continue onwards parallel to, and as it may be said fringing the line upon which the Canal runs as far as the 24th Mile, at which point and in the immediate vicinity of the Village of Jniwar we come in contact with one of them, which by being extended further to the south, forces us to cross it under the disadvantage of much heavy embankment.

This hollow, ordinarily term'd ~~which goes by the name of~~ the Jniwar Jheel, lies due east and west, it is in the form of a horseshoe with its toe

be rising on the village of [illegible]
which is on its western extremity;
the whole of this hollow is surface
below the Canal level and its
maximum depth below the country
in its neighbourhood is [illegible] feet; the
Canal Channel passed through
~~[illegible]~~ it to its full extent, and
the Canal having been more or less
filled with water during the period
that the works have been in progress,
some annoyance [illegible]
[illegible] operations;
its character however as a Jheel
holding a perennial supply
which was that assumed by the
native report, passed in the cold
weather of 1853, when we found it
dry or very nearly so, a circumstance
that may have arisen from the
Canal excavations, although the
Channel was completely cut off
from the influence of the [illegible] it
self by heavy embankments.
It will be understood from the
above description that a con-
-siderable portion of this hollow
lying to the right of the Canal,
~~[illegible]~~ cut off from its connection
with the Eastern and consequently
from its natural line of escape;
this has been remedied by ex-
-cavating a Channel from a
point on the extreme east of the
portion so cut off towards the
Hindun River, and by this means
relieving the country from any
ill effects caused by our inter-
-ference with the Jheel (see
Diagram No XXVIII). The Cut thus
made is in length 15[illegible] feet
with a breadth of [illegible] feet, its average
depth

depth here about 5½ feet, and I have no doubt that it will act in the most efficient way in relieving the country. The Eesun River which in the neighbourhood of the Canal [illegible] at a distance of about 2 miles from the course of the canal, bends abruptly to the [illegible] as it approaches to the village of [illegible]; and at the 31st mile of the course of the Canal, i.e. above the point where the high road between ~~[illegible]~~ Eyta [illegible] crossed, the River and the Canal are separated by a distance of 5 miles, whilst immediately eastward of the same point and to the village of Aurunt Bhogna, the canal comes in direct contact with the hollows of the Rinde, the tortuosities of the course of which are here very remarkable, its course in fact at the point in question is directly at right angles to that of its general alignment; it passes from west to East between the villages of Aurunt Bhogna and [illegible].

The strip of land over which the canal runs between the Eesun and the [illegible] Rivers is exceedingly narrow, its maximum width is [illegible] miles and at the village of [illegible] or on the 25th mile the width does not exceed 2¼ miles. The surface slope of the country from [illegible] to Aurunt Bhogna i.e. on a line of 3 miles is 42.36 feet or an average per mile of 1.41 feet. The bed of the Eesun [illegible] the country at the head of that River [illegible] the [illegible] part

of

[illegible] [illegible] [illegible] [illegible] [illegible] level than that of the [illegible]; as the [illegible] [illegible] [illegible] [illegible] when they [illegible] [illegible] [illegible] section, that is relative [illegible] of the drainage [illegible] its [illegible], at the 31st mile [illegible] [illegible] section [illegible] the [illegible] to [illegible] [illegible] shows that the [illegible] of [illegible] [illegible] 12 [illegible] feet below that [illegible] [illegible] [illegible], and the latter [illegible] [illegible] [illegible] elevation above the [illegible] throughout the whole length [illegible] [illegible] upwards.

[illegible] [illegible] of the Canal at the 31st mile is [illegible] in the [illegible] [illegible] [illegible], the width [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Regulator was 60 feet [illegible] by an [illegible] [illegible] of 4.12 [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ 11 feet.

Plan XXVII

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at 5 feet [illegible] [illegible] [illegible] [illegible] width to the [illegible] Channel, reduced to a maximum of 6 feet in the [illegible] [illegible] [illegible], the [illegible] [illegible] [illegible] [illegible] uniformly throughout the whole line at 8 [illegible] [illegible], or on the principle which has been adopted on the whole work at 2 feet above the high water mark. The remarks which I have before made on minimum section

[illegible] of [illegible] to the above diagram, [illegible] [illegible] [illegible] and [illegible] [illegible] used in widening the [illegible] to the [illegible].

[illegible] average depth of cutting on the line from [illegible] the ancient [illegible], in the first 30 miles of the [illegible] [illegible] is as follows.

From 1st to 11th [illegible] 6.53 [illegible]
11th to 21st [illegible] 7.75 [illegible]
21st to 31st [illegible] 4.1

The soil is good [illegible] [illegible] mixed with (5 [illegible]) gravelly in the neighbourhood of [illegible] ~~[illegible]~~ On the upstream side of the [illegible] from [illegible] until the 20th mile there are [illegible] of [illegible] [illegible] hills, and generally speaking the soil is [illegible] and better than it has been found in the upper [illegible] [illegible] [illegible] throughout the thirty [illegible] included in this [illegible] [illegible] [illegible] [illegible] 15 [illegible] [illegible] ~~[illegible]~~ ~~[illegible]~~.

At the [illegible] [illegible] [illegible] [illegible] there is a drop of [illegible] [illegible] the [illegible] [illegible] in the down stream [illegible] of the [illegible], the drop was necessary to avoid the heavy embankments that would have been required in advance had the Canal been retained on the higher level. Locks and a navigable channel have been designed for the purpose of overcoming the difficulty, and of facilitating the passage of boats; but the experience which we have obtained in [illegible] the

[illegible]

effects of these canals: these artificial causes, added to determine the bed slopes, by the natural arrangement of silt deposits, has led me to defer the construction of the works for the purpose of passing boats round this descent, until we can see the consequences of admitting water and the effect of a running canal upon the soil over which it passes. — I foresee the circumstance of a sudden reduction of slope from 15 to 12 inches would lead to silt deposits, and to an equalization of the slope of the canal, from a point considerably above that where the change in the amount of fall takes place, to many miles below it, and as I believe that this will take place, and as I do not calculate on any very immediate demand for navigation when the water is first admitted, I have considered that it would be unnecessary to press the execution of works the uses of which may be problematical. The observation of a few years will at any rate settle the question, and will determine whether my anticipations are true or not; if they are not true, the navigable channel and locks can be constructed [illegible] ~~without any difficulty~~

The maximum depth of wells, measuring from the surface of the earth to that of the water is by observation in the month of October equal to 50 feet, the minimum equal to 6 feet.—

The

The following Masonry works have been built on this line

1st Bridge at [illegible]pore, with a waterway of 99 feet in 3 arches of 33 feet each, [illegible] roadway [illegible] towing path arches, with Falls, [illegible] heads, [illegible] and 2nd Class Chokie attached. –

2nd Bridge at [illegible], roadway 15 [illegible], similar to that at [illegible]pore, with 2nd Class Chokie attached.

3rd Bridge at [illegible], roadway 15 [illegible], similar to that at [illegible]pore with an escape of 3 [illegible] of 6 feet each with 2nd Class Chokie attached.

4th Bridge at [illegible], 20 feet roadway, 3 arches of 33 feet each, with [illegible] towing paths, and Falls on the down stream

5th Bridge at [illegible] ([illegible]) same as at [illegible]pore with a 1st Class Chokie. –

6th Bridge at [illegible], roadway [illegible], similar to that at [illegible]pore, with a 2nd Class Chokie attached.

7th Bridge at [illegible], roadway 15 [illegible], similar to that at [illegible]pore, with 2nd Class Chokie attached.

8th Bridge at [illegible], roadway 20 feet, 3 arches of 32 feet each, with Falls, [illegible] and Inlet heads, [illegible] towing path arches and a 1st Class Chokie attached. –

9th Bridge at Bunde, 3 arches of 31 feet each, roadway 18 feet, with Falls [illegible] and a 1st Class Chokie attached.

10th Bridge at [illegible]udduny[illegible] – 3 arches of 30 feet each. Roadway [illegible] feet with Falls, [illegible] and [illegible] heads and a 2nd Class Chokie attached. –

[illegible]

Brick kunkur has been extensively used in all the above works, excepting in the bridges the material for walling which has been confined to Brick.

30th to 65th mile

From the Bridge at [illegible] [illegible] the high road between [illegible] and Allygurh passes, to the Bridge at [illegible] which is directly opposite the town of [illegible], and ~~[illegible]~~ on the line of communication between that town and [illegible], the distance is 30 miles. The line of canal continuing in the same course and in the same bearing as it did ~~[illegible]~~ to [illegible], making a slight curve to the left in ~~its approach~~ [illegible] to [illegible], to accommodate itself to the general alignment of the [illegible] between [illegible] and the [illegible], it bears [illegible] on its ~~approach to~~ [illegible] the neighborhood of [illegible], however, it bears away from the [illegible] and opposite the villages of [illegible] and [illegible], at the [illegible] mile it passes within a quarter of a mile of that River.

It has been before remarked that in the neighborhood of the 31st mile, and on the down stream side of the village of [illegible], the line of Canal comes in direct contact with the course of the River; the intersection of these two lines was unavoidable; it takes place at two points, the Canal

[illegible] a [illegible] ing a chord, [illegible] is [illegible] length, 1/6 of arc represented [illegible] that portion [illegible] is made [illegible] is cut off; the perpendicular or versed sine of this arc is about 1/6 miles

The following diagram will shew the position of [illegible] towns in this region, [illegible] their connection with the [illegible]

The [illegible] of [illegible] the case of the [illegible] the drainage [illegible] flows towards the [illegible], and [illegible] passage of the Rinde [illegible], [illegible] the [illegible] CD [illegible] continuous [illegible] drainage [illegible] the [illegible] AB, [illegible] that [illegible] the [illegible] separated [illegible] towards the [illegible] by the [illegible] movements, [illegible] all its spare water to the Rinde.

[illegible] portions of the [illegible] [illegible] the [illegible] of the [illegible] have been connected with the [illegible] by the cut EF leaving the region [illegible] between

[illegible]

[illegible] of [illegible] and [illegible] of similar dimensions to those before described. This Cut is in length 1573 feet, with a slope in bed equal to 1·336 feet per mile. The slopes in the levels at this part of the works, are such that it is possible that the [illegible] water in the [illegible] floods may [illegible] [illegible] [illegible] [illegible] to the [illegible] [illegible] [illegible] [illegible] is [illegible], this may [illegible] by [illegible] the [illegible] at a [illegible] point of [illegible], and I may [illegible] that the [illegible] the Gofoulpoor Bridge, as well as that at [illegible] India, will [illegible] [illegible] the [illegible] of the [illegible] point of the Canal [illegible] as [illegible] [illegible], will require careful watching, and [illegible] application of [illegible] adapted to the circumstances of the case. —

At the Gofoulpoor Bridge which is situated in the [illegible] formed by the Canal and the [illegible] of the Hindo[illegible] a 1st Class [illegible] post has been established with a view to the proper supervision and maintenance in efficient order of the different works in this neighbourhood.

From the [illegible] Bridge [illegible] the point where the Canal a second time intersects

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the Rinde River the line passes onwards without any interference with drainage until it reaches the 1st mile post [illegible] and at the [illegible] mile, a series of hollows connected with the Kesun River is crossed, a portion of its drainage being intercepted. The following diagram represents the line of drainage at Mohunpoor and [illegible], with the measures that have been taken to restore it to its proper equilibrium.

Diag: XXIX

From the [illegible] to the 65th mile [illegible] the [illegible] drainage [illegible] passes [illegible]; at the [illegible] mile, on the upstream side, ~~[illegible]~~ [illegible] the levels at the [illegible] Bridge, an escape into the Kesun river is established. At this point the distance from the Kesun is 9000 feet and the slope from the sill of the escape to the bed of the river is equal to 5·42 feet or on an average of 3·13, a foot per mile. This escape is also a water way of [illegible] sluices of 6 feet each, and the channel has been excavated in a width of

of 30 feet. This channel will be the ~~medium~~ means of disposing of the water which collects on the lands east of the villages of Chinguda, Nowani, Kachingua, &c., as well as of that with which the canal comes in contact at the 57th mile; ~~This~~ the drainage is comparatively small, but it will be effectively relieved by the Escape channel. Between the 61st and 62nd miles, however, at the village of Bhuraigaon, a regular drainage follows ... parallel with the Eesun river, and that portion of it which has been cut off ... is relieved by a cut of a mile in length made into the Rinde; the drainage at this point, therefore, is effectively provided for. At the 64th mile also, and at a point where the ~~line of~~ canal comes in close proximity to the Rinde river, ~~a large~~ drainage which rises in the neighbourhood of Nowanie crosses the line of canal; this ~~drainage~~ has been conducted into the valley of the Eesun by a cut AB as shown in the following diagram:

Diag: XXX

The strip of land lying between the

the Eesun and Hinde upon which the canal takes its course, consists of a series of narrow necks, connecting expanses of a width never exceeding 9 miles, the necks themselves in some cases (as at the 44th and 45th miles) not more than 2 miles in width. At the Singhpur Bridge, and at right angles to Singhpur, the width between the two rivers is equal to 6¾ miles, and the canal passes within 1 mile of the Hinde.

The slope of the surface of the country from the 31st to the 66th mile is equal to 43·28 feet, or an average equal to 1·24 feet per mile. The levels as at the following points show the relative position of the beds of the Hinde and Eesun to each other.

41st mile	Bed of Eesun	4·3	[illegible]	of Hinde
49th	Do	Do	7·65	Do
* 57th	Do Mainpuri	Do	9·7	Do
65th	Do	Do	15·46	Do

The bed of the Eesun it will be observed increases in depression below that of the Hinde as it advances in its course, the Eesun in fact at Mynpoorie is a perennial River (supplied by springs which rise on its approach to the [illegible] [illegible] passing through a very extensive valley; its value during

* The cross section at the ford the Bridge of the Cawnpore road near the village of Mynpoorie at which it is 24·5 feet below the bed of the Hinde. The East Kali Nuddi in the month of April when I took the section, its water was running slowly and sluggishly and full of weeds, the width of surface was 115 feet and the greatest depth 3·4 inches, both the bed and the banks in the neighbourhood were [illegible]

during floods may be estimated by the waterway of the Bridge which is built across it on the high road between Cawnpore and Agra, the bridge consists of 9 bays of 31 feet each in width, & connected to the high road by raised embankments or ramps of approach. This waterway is in all probability somewhat contracted, as the bridge appears to have been injured by a flood as far back as the 21st March 1833; but it has nevertheless done its duty for a period of 21 years, and altho' [illegible] and imperfect [illegible] requiring modification to meet the improved and the raised approaches that have been lately made, the bridge itself as far as waterway is concerned would most likely be sufficient for all practical purposes. The necessity, however, for using the Esun as an Escape from the Ganges Canal works, in consequence of the depth and capacity of the channel of the Nudee being insufficient, will render an enlargement of the waterway of the [illegible] bridge necessary, and in this case the opportunity might be taken of carrying into effect the alterations recommended in 1833 by Col. John Boileau of the Engineers in increasing the waterway; instead, however, of giving an additional width of [illegible] feet, I would give 3 additional arches of 31 feet in width, two on the North, and one on the South

of the present building – giving
Since this is a long and spacious
aqueduct, while it would make
the roadway over it horizontal. –
The Bridge over the Trent
at Newark has a waterway of
{Spring of arch 121½ / Foot of piers 111 feet} divided into 3
Bays of {40½ feet / 37 feet} each, without any
appearance of being a running
stream where the Canal passes
to the great and apparent fer-
tilization of the country in
its immediate neighbourhood.

The Section of the Canal
Channel at the 6th mile is
as follows: –

Section at the 6th mile   DIAG: XXXI.

a gradual reduction having
taken place in the width of the
rectangular channel equal to
128 feet in every 3 miles, the
Minimum dimensions are here
retained in the same way as
formerly; the height of the mound or
towing path above the bed of
the Channel being nearly on an
average of 6 feet, and
where that has been exceeded
beyond that required for the
Minimum Section, the earth
in excess was thrown back on
the embankments so as to increase
as much as possible the width
of the [illegible] roadway. –

The average depth to which
the Channel has been excavated
between the 31st and 60th miles
are

are as follows.—

From the 31st to 41st mile	7.21
Do 41st to 51st Do	6.94
Do 51st to 61st Do	5.0
Do 60th to 62nd Do	7.02

The soil continues in the whole extension of the same [illegible] quality, occasionally mixed with [illegible] as it was on the [illegible] higher [illegible]; [illegible] the effects of rain water which during the progress of the works lodged in the channel. It is ~~[illegible]~~ mostly absorbent, and throughout its whole course the influence of salt efflorescence is markedly remarkable. This kind of efflorescence is characteristic of the whole line of the [illegible] District through which the Canal is carried, it shows itself more or less on the surface, influencing to a great degree the extent to which cultivation is carried, and in many parts of the excavated channel it shows itself at depths considerably below the ~~surface~~ the ground. The brick manufacturers have suffered greatly from the soil being impregnated with this most destructive Alkali, and the consequences have been in many cases altogether fatal to the manufacture of bricks, whilst on the whole line there has been a difficulty in procuring this species of material, which has been unknown in the [illegible] Districts, ~~through which the Canal has been carried~~. The slope in the Canal bed throughout the 35 miles included in this section

is 15 [illegible] per mile –

The maximum depth from the surface of the roadway to the surface of the water in [illegible] is equal to 35 feet, and the [illegible] 15 feet, [illegible] observations [illegible] made in the [illegible] of [illegible]

The following bridges have been constructed between [illegible] and [illegible]

1st Bridge at [illegible] 3 [illegible] of 31 feet each 15 feet roadway with [illegible] and [illegible], and 2 [illegible]

2nd Bridge at [illegible] 3 [illegible] feet roadway [illegible]

3rd Bridge at [illegible] at [illegible] roadway 21 feet [illegible]

4th Bridge at Kooreet 3 [illegible] of [illegible] feet each. 18 feet roadway [illegible]

5th Bridge at [illegible] 3 [illegible] 15 feet roadway [illegible] 1st [illegible]

6th Bridge at [illegible] 3 [illegible] of 28 feet each, 10 feet roadway [illegible]

and

and brick heads; [illegible] [illegible] [illegible] with a wide wing of 30 feet on the upstream side of the body of [illegible] brick [illegible] attached to these works.

7th Bridge of [illegible]
3 arches of 27 feet, [illegible] 18 feet roadway with [illegible] of brick heads, and [illegible] [illegible] attached.

8th Bridge of [illegible].
3 arches of 27 feet, 18 feet roadway with [illegible] of brick heads, and 2 [illegible] attached.

9th Bridge of [illegible]
3 arches ~~[illegible]~~ of 26 feet each, 23 feet roadway, with [illegible] of brick heads, and [illegible] attached.

10th Bridge of [illegible]
3 arches of 26 feet each, 20 feet roadway with [illegible] of brick heads and [illegible] attached.

11th Bridge at [illegible]
3 arches of 26 feet each, 20 feet roadway with [illegible] of brick heads, and [illegible] attached.

In all the above works, [illegible] has been very extensively used, the [illegible] of [illegible], in brick manufacture, and the [illegible] quantity of bricks, would in fact, have ~~[illegible]~~ delayed the completion of these works [illegible] at the

present

presence of numerous Indians who [illegible] in the districts through which the Canal is now passing. The Treatment is excellent, and it requires to be carefully attended, and in all cases the sick should have been seen and [illegible] have been repeatedly [illegible] by the Medical Officer.

[illegible] our journey on another 33 miles, or from the 65th to the 100th mile, we reach the neighbourhood of Lucca and Arousa, the villages being intimately connected with the history [illegible] as previously [illegible] — 65th to 100th mile

The direction of the line [illegible] after passing the 2d [illegible] is a few degrees more Southerly than it was in the other part of its course, the direction being influenced by the course of the Rindi, to which in this [illegible] line it runs in great approximation, — in the neighbourhood of the village of [illegible] and at the 80 mile, at which point the line of Canal and the river are in very nearly in contact, the former takes a slight bend to the right and proceeds onwards in a straight line upon the village of [illegible]. The course of the [illegible] throughout the whole of the 35 miles now under review, runs on the most tortuous lines; although [illegible] maintaining the parallelism to each

each other, the contrary [illegible]
[illegible] occupies the greater
part of the intervening land,
and in [illegible] [illegible] made
[illegible], the canal [illegible]
[illegible] and [illegible] with the greatest
attention to this particular fea-
ture of the [illegible], and it
passes as directly upon the crest
of the watershed of the 2 Rivers
as a straight line could possibly
do upon a tortuous one; from
the 65th to the 75th mile, the
drainage is [illegible]; the natural
flow towards the Rinde on the
right, and to the Isun on the
left, is unimpeded; the town
[illegible] of [illegible], situated
on a high mound to the left and
[illegible] by [illegible] extensive
hollows, is passed without the
drainage of its neighbourhood
[illegible] with any check or im-
pediment. At the 78th and 83rd
miles, we come in contact with
cross drainage under circumstances
of rather a peculiar nature; in
the first case, a series of shallow
depressions extending from the
high mound on which the village
~~at~~ and old Fort at Bulgram
are situated crosses the line of
canal and proceeds to the Rinde;
and in the 2nd case we come
at the village of Dhundos upon
a well defined crest of two valleys
one of which passes by the village
of Bussumpoorah to the Isun, and
the other runs into the Rinde
from the south of the village
of Dhundos. This village is in

cut.

ed built on the rock and the
tions there two [illegible] of drainage
each of which is about 1800 feet in
length, one on each side of the
the Canal has been constructed.
The bottoms of these [illegible] below
are, as is [illegible] the case, [illegible]
[illegible] but [illegible] are [illegible]
[illegible] connected with [illegible]
for the purpose of irrigation,
the remains of lands at the back
[illegible] have been under cul-
tivation as far back as the
time of [illegible] as the [illegible]
of [illegible] and in the hollows
connected with the [illegible], being
[illegible] constant occurrence. At
the head of the Husseinyeh [illegible]
and on the outfall line [illegible]
drainage of these [illegible]
[illegible]; the extent, however,
is inconsiderable; at the period
of my survey in the month of
[illegible] there was no appearance
of moisture in [illegible] either
[illegible] and [illegible]
~~[illegible]~~ for [illegible]
[illegible] after the [illegible]
[illegible]; it is desirable that after
after water is admitted into the
[illegible] the [illegible] of
[illegible] in these hollows will
be [illegible].

To remedy the evils arising
from the interference with the
outfall drain, a [illegible] has
been designed for the purpose
of keeping the flood water to
the right of the Canal and on-
wards to the Husseinyeh

nullah

Canal, the point at which this canal commences is taken in the deepest part of the Mill-pond, almost opposite the [illegible] [illegible] and opposite to that point in the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water is [illegible] [illegible] [illegible] a [illegible] slope of [illegible] feet [illegible] [illegible] will [illegible] the water [illegible] to the [illegible] [illegible] [illegible] it will pass directly through the [illegible] [illegible] [illegible] that [illegible] [illegible] it will pass [illegible] the right and close to the village of [illegible] and at the distance of 3 miles will [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] the village of [illegible] [illegible] [illegible] [illegible] through the Mill-pond, will give the water a new draft into the [illegible] river, and [illegible] will [illegible] to the [illegible] Mill-pond downwards.*

The following Diagram will give a more accurate idea of the course and of the position of the towns in this neighbourhood than

---

* Economical considerations have led to deviations from the above design. The water from the Mill-pond [illegible] [illegible] as at [illegible] [illegible] [illegible] [illegible] with the [illegible] [illegible] [illegible] which has been [illegible] with [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water, it is now [illegible] with the [illegible] of the [illegible] [illegible] [illegible] [illegible] passing to the [illegible] of [illegible] [illegible] [illegible] [illegible]

than [illegible] in description

Diagram XXXII

A B [illegible] of Cut [illegible] Hutpaon
[illegible] Hussunpoor Nulla

From the [illegible] to the 100th mile, the Canal although passing over a [illegible] [illegible] [illegible], [illegible] [illegible] and [illegible] [illegible] and at one point almost touching the [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible], without in any way interfering with [illegible] [illegible] of the Eesun or Rinde [illegible] [illegible] [illegible]. On the [illegible] [illegible] [illegible] as the [illegible] [illegible] and situated at the 7th mile, the Ganges Canal [illegible] [illegible] [illegible] [illegible] [illegible] into the Eesun [illegible], [illegible] [illegible] [illegible], this [illegible] has a [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] similar [illegible] [illegible] which have been built in the [illegible] [illegible] [illegible] [illegible] plan and section of this work will be found in the Atlas Plate XXXIX. [illegible] [illegible] [illegible] between the beds of the Rinde and Eesun on a cross section taken on

on Visca is 16 & feet, the Escurr as I have before remarked, running [illegible] through [illegible] [illegible] than the [illegible]. The two Escurrs are on this side [illegible] practically represented; the [illegible] of the [illegible] and [illegible] [illegible] [illegible] of [illegible] wells depends, [illegible] with [illegible] and are [illegible] about 10 feet below the bed of [illegible]; the Escurr on the [illegible], with [illegible] [illegible], and with its banks [illegible] with sand hills, runs in [illegible] [illegible] of [illegible] [illegible] and [illegible] from the [illegible] of the water. It must, however, be understood that the [illegible] [illegible] of the [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], the [illegible] are [illegible] [illegible] with cultivation, but the difference [illegible] and the [illegible] of the Escurr [illegible] which [illegible] [illegible] [illegible] [illegible] [illegible], and in the [illegible] [illegible] water is found at [illegible] distances [illegible] the surface is [illegible]; the [illegible] [illegible] [illegible] [illegible] the Escurr, moreover, [illegible] [illegible] higher quality [illegible] that [illegible] the [illegible], the latter being [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] with [illegible].

The distance between the [illegible] and the Escurr at the point where the Escape is built is [illegible] feet, and the difference of level between the sill of the Escape and the bed of the Escurr is equal to [illegible] [illegible] [illegible]

[illegible]

the [illegible] is 30 [illegible] wide, with
a [illegible] of 1·5 per [illegible]. The
[illegible]
[illegible]
[illegible] therefore
[illegible]
the first fixed upon, was the desire
to have the Buttington [illegible]
for the purpose of the [illegible]
[illegible]; the [illegible] of this [illegible]
as well as that of the artificial
[illegible]
~~[illegible]~~
~~[illegible]~~
it, is a good and a rapid one,
and the advantages of [illegible]
[illegible]
[illegible] desirable,
[illegible] this par-
ticular point, [illegible]
[illegible] was a [illegible]
[illegible]
than there would have been [illegible]
the Buttington [illegible]

[illegible] throughout the
whole of these [illegible] miles [illegible]
[illegible], [illegible]
the natural boundaries with
which it has [illegible] running paral-
lel with [illegible]:
the [illegible] and [illegible] which
constitute these boundaries
[illegible] regard to [illegible]
the same [illegible]
generally [illegible] parallel
course, at one time approaching
to within a short distance, and
at another [illegible] in
the most [illegible] a series
of curves and tortuosities.
[illegible] the definition

of

[illegible] [illegible] a [illegible] of [illegible] which separates it entirely from the [illegible] [illegible], [illegible] [illegible] [illegible] to the [illegible] [illegible] [illegible] with the [illegible] [illegible] which it has [illegible] [illegible] [illegible] separation [illegible] they are [illegible], at this point the width between the two [illegible] is equal to 1½ miles, [illegible] [illegible] [illegible] towards the [illegible] [illegible]. With the exception of that [illegible] [illegible] near the village [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] within 3 miles of each other, the average distance [illegible] [illegible] [illegible] the 65th to the 100th mile may be considered as about 6½ miles.

[illegible] 27 ; V. [illegible] [illegible] the [illegible] [illegible] [illegible] the 65th to the 100th mile is 24.15 feet, which is equal to 1.11 feet per mile. [illegible] [illegible] [illegible] [illegible] the water shed between the two [illegible] as closely as possible, and as [illegible] [illegible] [illegible] [illegible] approximation to the [illegible], than to the [illegible], a circumstance depending [illegible] on the position of the [illegible] [illegible] [illegible]. [illegible] [illegible] at the following points [illegible] the relative position of the [illegible] of the [illegible] and [illegible] to each other.

7th mile the [illegible] [illegible] is 6.35 feet [illegible] [illegible]

65th	do	[illegible] feet	do
87th	do	16.65 feet	do
100th	do	[illegible] feet	do

The gradual increase of [illegible]

[illegible]

of the [illegible] of the Ganges [illegible] that of the [illegible] is [illegible] as [illegible] the [illegible] 35 miles distinctly observable: the fact is [illegible] of notice, as it points out the Ganges [illegible] as [illegible] [illegible] useful [illegible] of waste water from the canal, [illegible] the slope of [illegible] [illegible] aside the tortuosity of channel which is common to [illegible] rivers, is ill adapted in this part of its course for the purposes of escape.

The section of the canal channel at the 10th mile is as follows:

Diag. XXXIII

an actual reduction of slope per mile having taken place in the 35 miles just described.

[illegible] the [illegible] 15 [illegible] is reduced to 1½ [illegible] per mile, [illegible] at [illegible] to the 41st mile. At this point [illegible] the 41st [illegible] 10½ [illegible] [illegible] instead of giving a sudden drop as at [illegible] and [illegible] the slope in advance of 12 inches per mile, designed [illegible] slope [illegible] [illegible] [illegible] of [illegible] a plane. The

[illegible] perpendicular [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible],
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible].

[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible]

[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible], [illegible] appearances [illegible] [illegible] [illegible] qualities, [illegible] the use of Brick masonry ~~[illegible]~~ [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], the works in this Division could not possibly have been complet-ed at [illegible] period that

[illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] 33' 25 [illegible] [illegible] 16 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] 25 Miles, [illegible] [illegible] [illegible] [illegible]

1st Bridge at [illegible]

2 [illegible] of 33 [illegible] 15 feet roadway with [illegible] and [illegible], [illegible] [illegible] [illegible].

2nd Bridge at [illegible].

2 [illegible] of 33 [illegible] 10 feet roadway with [illegible] and [illegible], [illegible] 1st Class [illegible].

3rd Bridge at [illegible].

2 [illegible] of 33 [illegible] 15 feet roadway with [illegible] and [illegible], [illegible] 2nd Class [illegible].

4th Bridge at [illegible]dh

2 [illegible] of 33 [illegible] 15 feet roadway with [illegible] and [illegible], [illegible] [illegible].

5th Bridge at [illegible].

[illegible] of 33 [illegible] 15 feet roadway with [illegible] and [illegible], [illegible] 5th Class [illegible].

6th Bridge at [illegible].

2 [illegible] of 32 [illegible] 15 feet roadway with [illegible] [illegible]

[illegible] roads, and a 2nd Class Chokee attached.

7th Bridge at [illegible] 2 arches of 31 feet each 20 feet Roadway with [illegible] roads, and [illegible] attached. ~~[illegible]~~ the Bridge [illegible] of 6 feet [illegible] placed between the arches.

8th Bridge at Futtypoor 2 arches of 31 feet each 18 feet roadway with Ghats, Rajbuha and [illegible] roads, and 2nd Class Chokie attached.

9th Bridge at Mirzapoor 2 arches of 30 feet each 20 feet roadway with Ghats, Rajbuha and [illegible] roads, and 2nd Class Chokie attached.

10th Bridge at [illegible] 2 arches of 30 feet each 18 feet roadway, with Ghats, Rajbuha and [illegible] roads, and a 1st Class Chokie attached.

11 Bridge at [illegible]reya 2 arches of 30 feet each 20 feet roadway with Ghats, Rajbuha and [illegible] roads, and a 2nd Class Chokie attached.

[illegible] the point of the [illegible] [illegible] the main Canal continues its course [illegible] towards Allahabad [illegible] ([illegible] 3rd project of 1845) [illegible] the left bank of the Rinde River to the Jumna

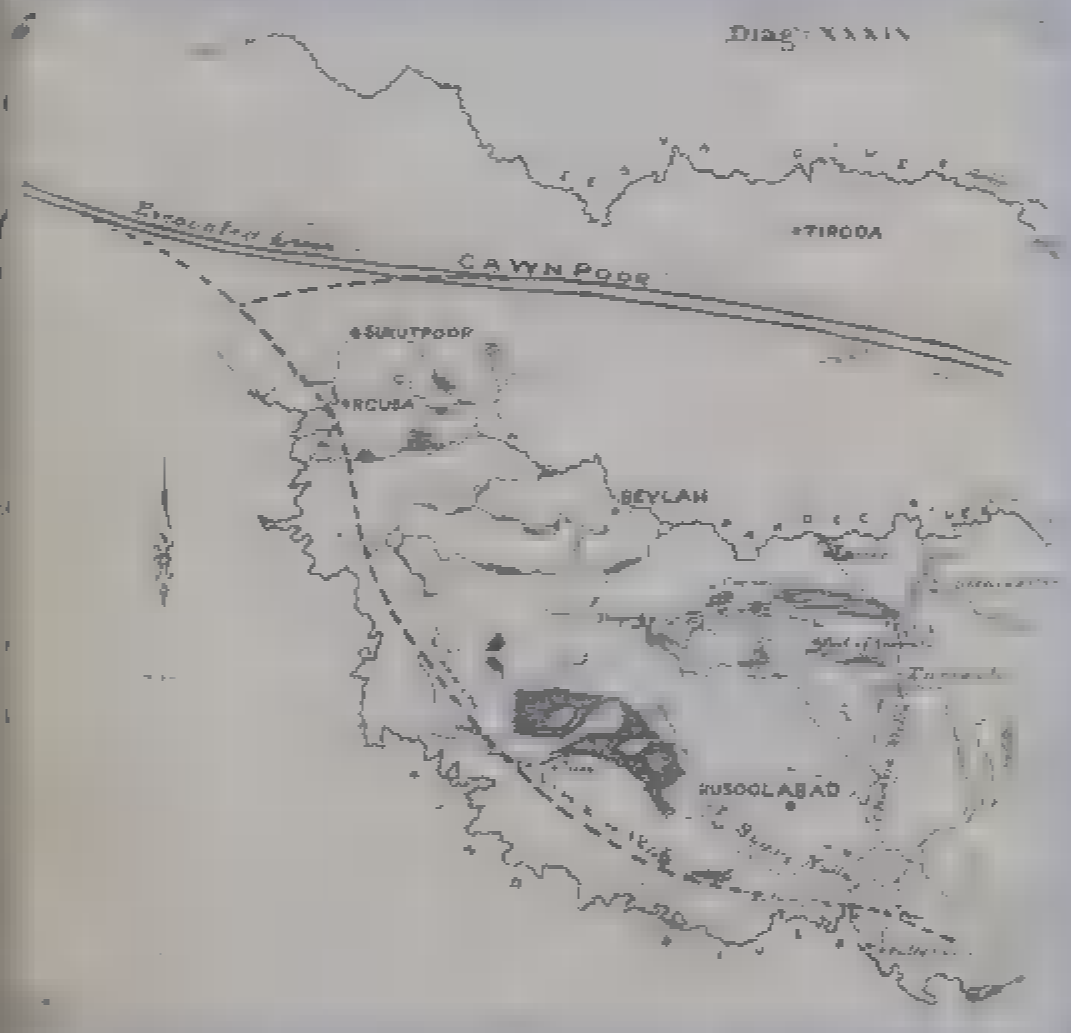
[illegible]

~~not far from~~ near [illegible] of [illegible]
This [illegible] as far as the
village of [illegible], was [illegible]
the same as that upon which
the [illegible] [illegible]
From [illegible] [illegible] [illegible]
straight [illegible] [illegible]
the [illegible] [illegible]
[illegible] passing [illegible] the [illegible]
of Tousa, [illegible] [illegible] [illegible]
[illegible] [illegible] at [illegible]
[illegible] [illegible] situation [illegible]
[illegible] [illegible] [illegible] [illegible]
the [illegible] [illegible] [illegible],
~~[illegible]~~ d [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] at a [illegible] [illegible]
[illegible] [illegible] [illegible] the
head of the [illegible] [illegible] the
[illegible] [illegible] [illegible] and down
[illegible] the [illegible] [illegible] [illegible]
the [illegible] [illegible] the village
of Tousa, [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] the
[illegible] position [illegible] [illegible] [illegible]
would [illegible] actually at the point
so laid down, or at any intermediate
[illegible] between that place and the
village of [illegible]. [illegible] [illegible] at
[illegible] [illegible] [illegible] [illegible] had [illegible]
[illegible] [illegible] as that [illegible]
[illegible] [illegible] the [illegible] [illegible]
[illegible], [illegible] passing [illegible] the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
which [illegible] at the [illegible] [illegible]
[illegible] of [illegible] [illegible]
would have been avoided.
The village of Tousa is
the

be near to the passage of ~~this~~ that part of the Tonk; ~~at this point~~ by [illegible] the heads of the Sindoo [illegible] which [illegible] pass [illegible] [illegible] [illegible] to [illegible], [illegible] it would save [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] courses [illegible] [illegible] [illegible] now [illegible] [illegible] ~~[illegible]~~ ~~[illegible]~~ [illegible] [illegible] to [illegible] [illegible] [illegible] and [illegible] ~~[illegible]~~ of [illegible] [illegible] the upper part [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] near the village of [illegible], situated upon that [illegible] at a distance of 17 [illegible] [illegible] Isbead. The waters [illegible] [illegible] [illegible] [illegible] flows through [illegible] [illegible] a series of [illegible] flats on which the high mounds [illegible] [illegible] [illegible], [illegible] [illegible] are situated. ~~[illegible]~~ to the [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] the Sindee [illegible] [illegible] Poo [illegible] Bullunjong [illegible] part [illegible] the Triangle [illegible] by the Pandoo [illegible] river runs from West to East, the [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the drainage to pass off to the Sindee, the natural line of watershed being close on the Right side of the Pandro, a [illegible] [illegible] marked and [illegible] [illegible] as a watershed [illegible]

is

be [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]



[illegible] AB [illegible]

The main line of 1845, it will be [illegible] [illegible] [illegible] [illegible] course [illegible] the right [illegible] [illegible] [illegible] [illegible] and [illegible] of [illegible] [illegible] [illegible] and Arwin, [illegible] [illegible] bank of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the above diagram [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] it by Aqueducts [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the East, [illegible] [illegible]

[illegible] over the [illegible] to the west
of the village of [illegible]poor.
[illegible] levels [illegible] across the Sands
and the [illegible], and the country
[illegible] between [illegible] the land
[illegible] [illegible] Nussa [?] [illegible]
~~[illegible]~~ as follows:-

Top of the Sandbed above	27 7/12 feet
[illegible]	29.89
[illegible]	49.88
[illegible]poor [illegible]	48.83
[illegible]	47.77
[illegible]	37.66

[Marginal note, written sideways: [illegible] level of the [illegible] under the [illegible] [illegible] foundation of the [illegible] Nulla [?]]

[illegible] description ~~of the position~~ of the [illegible] of the course of the [illegible] and the relative levels with regard to the Sands, and the country to the South and to the right of the [illegible] of the ^rising land, ~~[illegible]~~ will enable me to [illegible] any [illegible] [illegible] without [illegible]. I may observe, however, in the body of my [illegible] report, and in recapitulating of what I have before said, that the [illegible] which takes its rise from the swampy ground in the neighbourhood of [illegible], has its main sources at the junction of the [illegible] [illegible] and [illegible]poor Districts; it runs parallel to and [illegible] of the [illegible] River on a much higher level, and in the early parts of its course exhibits a section of small dimensions with a velocity of [illegible] [illegible] [illegible] per [illegible], during any floods this [illegible] to a point at [illegible] [illegible]

of Arles, overflows its banks,
and [illegible]
its [illegible] of water into the [illegible]
River through [illegible]
Communicating [illegible]
of Arles [illegible]
[illegible] Marius and [illegible]
conducted [illegible]
into a distinct [illegible]
[illegible]
Rhone, [illegible]
[illegible]
has [illegible]
the [illegible] at the
[illegible]
[illegible]
[illegible]
from Arles [illegible] to
the [illegible] Port,
[illegible]
[illegible]
high water [illegible]
[illegible]
on the right bank [illegible]
[illegible]
[illegible] the [illegible]
water would [illegible] down
the [illegible]
[illegible]
the [illegible] two feet
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] connecting
the [illegible] with the [illegible] at
[illegible]

Nimrana and Nujfa, for the purpose of supplying water for irrigation to the lands of these latter villages. The Pandwo and Nimdi [illegible] these we have seen to be both naturally and artificially [illegible] with such [illegible]. I would refer however for further explanation to Plate No. IX and the details in which the most detailed examination of this part of the country is [illegible].

Proceeding onwards from the 100th to the 135th mile we reach the 1st class Locks and Station of Nuhwan. In this line the direction of the Canal is, as has been invariably the case during its passage between the [illegible] and [illegible], regulated by the course of the levels, maintaining its position as far as possible on the watershed; in the present case the bearing on the nearing the 100th mile is a continued prolongation of that which had preceded it for a short distance. It then takes a gradual sweep to the left, keeping to the right its [illegible] close to the high grounds and fields in Aulleepore, [illegible] and [illegible]; from thence the line proceeds onwards still keeping on a [illegible] course of East until it reaches a point about half way between the towns of [illegible] Tirroo and Tuttaon, when it takes a sweep round to the South

[illegible]

reaching the 135th mile at the village of [illegible] which is situated at a distance of a mile from the [illegible]. The Canal in this portion of its course forms an [illegible] the lower ground [illegible] with a [illegible] [illegible] the bed of the [illegible] the road [illegible] [illegible] [illegible] ultimate amounts of the [illegible] that [illegible] require. Its [illegible] will be best understood and appreciated by a reference to the map (Plate No IX Atlas)

At the 1[illegible] mile the [illegible] of drainage [illegible] [illegible] [illegible] [illegible] near the village [illegible] the heads of this drainage [illegible] [illegible] [illegible] below of about 2 [illegible] miles [illegible] [illegible] [illegible] to the [illegible] is situated within the distance of a mile of the Canal to which it lies parallel; and the [illegible] of the hollow [illegible] the road [illegible] the drainage is about 2 miles from the point [illegible] with the Canal at the village of [illegible]; at its approach to this village it assumes the form of a tortuous and well defined nulla, and its inclination towards the line of works is unmistakeable. From the deepest part of the

[illegible]

[illegible] to the [illegible] of the [illegible] on the [illegible]
[illegible] 3 [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] after
[illegible] about
[illegible]
[illegible]
[illegible]
point of the [illegible]
[illegible]
[illegible]
[illegible] has been made by
the [illegible]
[illegible] the [illegible]
[illegible] with
the [illegible] for the purpose of
[illegible] of the
[illegible] for [illegible]
the length of this [illegible]
[illegible] is about [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

to

Diag: XXXV

It is [illegible] that I [illegible] the Canal at [illegible], the actual distance [illegible] of the [illegible] miles, [illegible] A to B is equal to [illegible] feet, the bed [illegible] has a declivity of 6.6 feet per mile. —

[illegible]

the Kursowa Bridge is 1190 feet above that is the bed of the [illegible] at the point where the [illegible] [illegible] joins it at Ulla. The distance in the [illegible] being 11½ miles. –

[illegible] [illegible] at the Kursowa bridge which is three feet [illegible] will pass [illegible] [illegible] of a [illegible] [illegible] constructed [illegible] [illegible] [illegible] may [illegible] [illegible] [illegible] [illegible] each at least [illegible] [illegible] to the [illegible] [illegible] to Ulla. [illegible] [illegible] [illegible] the [illegible] [illegible] available [illegible] [illegible] [illegible] [illegible] annually [illegible] [illegible] in the [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] marked [illegible] the above diagram CDEF has been made [illegible] [illegible] [illegible] near Ulla [illegible] [illegible] [illegible] to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] towards the [illegible] [illegible] [illegible] [illegible] of the country [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] will [illegible] no difficulty in [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible].

[illegible] the [illegible] [illegible] the [illegible] [illegible] passes [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] drainage [illegible] country [illegible] [illegible] [illegible] or hollows [illegible] the [illegible] under the Forts at Ba[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

towards the [illegible] and the Country
lying to the right [illegible] the [illegible]
Shoal of [illegible] [illegible]
of [illegible], [illegible] is covered
with [illegible]
from the [illegible] to the [illegible]
At the [illegible] [illegible]
South [illegible], which [illegible]
on [illegible] of the [illegible]
mounds, [illegible] this part of
the [illegible] is [illegible]
Canal at the 11th mile it its
course [illegible] with
a [illegible] of considerable
dimensions; [illegible]
[illegible] doubt [illegible]
and [illegible]
and [illegible] doubtless
on the [illegible] between
the [illegible] and towards the
[illegible]. [illegible]
as in the case of the Summit
Sheet [illegible] referred to, although
the [illegible] dip [illegible]
is towards the [illegible]
although the natural [illegible]
from the [illegible] sheet [illegible] to
the [illegible]
[illegible]
[illegible] and [illegible]
[illegible] with [illegible]
[illegible] connected [illegible]
[illegible], that had it [illegible]
[illegible]
[illegible] examination of
the country [illegible]
the [illegible] would have
been discovered, as in the Summit
Sheet also there are two cuts made
by the [illegible] from the

[illegible]

Southern face one on the west and the other on the east of the rock in Goshen, the former leading the water from the [illegible] into a large hollow, on which a [illegible] has been thrown for the purpose of forming a reservoir for irrigation, the latter [illegible] the supply to a series of hollows lying to the eastward beneath which is a series of bunds applicable to the same purpose, and all of them put to use annually during the rainy season —

Both the cuts above mentioned [illegible] the [illegible] well [illegible] towards the [illegible] [illegible] on the watershed, and it will be interesting for the reader to [illegible] upon which the [illegible] of this particular part of the country has been ~~[illegible]~~ (Plate IX Atlas) that ~~the~~ he may understand the nature of this network of drainage ~~may be fully understood~~.

[illegible] of the 116th mile the canal passes over level country until it reaches the 121st mile at [illegible]; at this point it crosses a low bank [illegible] on the watershed, [illegible] on the west a large hollow situated to the north and under the [illegible] and on the east a more extensive and [illegible] depression of country lying to the south of the village of [illegible] —

extra-

between that village and the line of march. At [illegible] 1.15 this [illegible] upon [illegible] the [illegible] the [illegible] with [illegible] the water [illegible] flows into the [illegible] — [illegible] the Yo[illegible] [illegible] with the [illegible] land [illegible] and the [illegible] the [illegible] ground [illegible] the [illegible] and [illegible] the water [illegible] passes, separating [illegible] from the low land of [illegible] and Chungurun.

changing the direction of the drainage from the neighbourhood of the [illegible] [illegible] towards the [illegible], which lies at a distance of [illegible] miles, running [illegible] a long valley bounded by [illegible] [illegible] are pierced in the direction of Rohtas by two or [illegible] well defined tributaries of the [illegible] of the drainage. It is possible that the relief of the many inundations near [illegible] may be facilitated by an artificial cut* made from that neighbourhood to another [illegible] to the [illegible] of these [illegible], and it [illegible] necessary [illegible] [illegible] [illegible] at [illegible], [illegible] [illegible] with the operations which have been carried on during the progress of the work. [illegible] [illegible] in this place remark that although the [illegible] [illegible] lines [illegible] the above purpose evidently [illegible] not [illegible], would [illegible] [illegible] and [illegible] to the [illegible] of the country, by rapidly carrying off rain water to the low [illegible] during [illegible] [illegible] and [illegible], [illegible] by so doing cause considerable injury to the [illegible] [illegible] at present [illegible] the supply for the purposes of [illegible], such are [illegible] so many [illegible] [illegible] the water [illegible]; [illegible] for the introduction of canal water, and the system of regular irrigation

[illegible]

*[illegible] has [illegible] since
[illegible] written.

the [illegible] ground, [illegible] of
the [illegible] [illegible] [illegible] the
cultivating [illegible] [illegible] [illegible],
but it would be [illegible]
[illegible]
[illegible]
[illegible] a substitute, [illegible]
[illegible] [illegible] [illegible]
drainage [illegible]
than that [illegible]
[illegible] [illegible]
tains is a state of equilibrium
to the passage of water.

[illegible] the B. [illegible]
direction to the [illegible] [illegible]
[illegible] [illegible]
[illegible] the drainage [illegible]
runs towards the [illegible]
[illegible], and [illegible]
[illegible] parallel [illegible]
a distance of [illegible]
[illegible] at the 133rd [illegible]
[illegible] [illegible]
[illegible]
branch of the [illegible]
[illegible]
with an [illegible]
hereafter described, [illegible] towards
the [illegible], and [illegible] passing
[illegible], the water that
[illegible]
[illegible], and [illegible]
[illegible] with the [illegible]
drainage [illegible] ~~[illegible]~~
~~[illegible]~~ [illegible]
artificial causes; at [illegible]
the drainage [illegible]
by the canal, which passes
towards the village [illegible]
[illegible] without any [illegible]

water

Willshire

[illegible]atmosphere.

[illegible] [illegible] [illegible] be [illegible] [illegible] upon [illegible] account of [illegible] its connection with the [illegible] (in [illegible] the [illegible]) [illegible] a considera-ble distance, parallel, it requires [illegible] [illegible] preparation.

[illegible] [illegible] the [illegible] and to the [illegible] [illegible] the Canal [illegible] [illegible], subsequently, [illegible], and [illegible] places [illegible] [illegible], situated on [illegible] ground, it might be called a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] causes. [illegible] would [illegible] [illegible] the influence of the roads [illegible]. Both sides [illegible] [illegible] [illegible] of drainage [illegible] is [illegible] [illegible] remarkable [illegible] in connection with [illegible] water [illegible] of the atmosphere; from the [illegible] of the [illegible] [illegible] and [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the country, [illegible] which the Canal passes, [illegible] [illegible] [illegible] constant occurring in the neighborhood [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the neighborhood of the [illegible] [illegible] [illegible] and at that point where the Canal [illegible] [illegible] [illegible] [illegible] most [illegible] [illegible] [illegible] [illegible] both [illegible] the [illegible] [illegible] change

[illegible]

[illegible] out, [illegible]
[illegible]
difficult [illegible]
[illegible], ~~[illegible]~~
~~[illegible]~~
~~[illegible]~~ [illegible]
[illegible]
[illegible] ~~[illegible]~~
[illegible]
[illegible]. [illegible] in all
~~[illegible]~~ probability [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]. ~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~ [illegible]
these exciting scenes transpiring in
[illegible]
[illegible]
[illegible]
[illegible].
[illegible]
that the mounds [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the descending
country

covering the [illegible]

10 feet. [illegible] with

[illegible]

[illegible] of

[illegible]

[illegible] position

above the [illegible] of the

ruins, and the [illegible]

[illegible] a [illegible] annually

[illegible]

[illegible] of the [illegible] instead

[illegible] and at the foot of the steps

[illegible] the mounds are

described as at [illegible], and the

[illegible] is altogether attached

[illegible] situated

to the neighbourhood. [illegible]

no doubt that [illegible] these

mounds, although [illegible]

[illegible] are so [illegible] as

those [illegible] the [illegible]

would add greatly to the eluci-

dation of their early history.

[illegible] foundations built

[illegible] of [illegible]

[illegible] the [illegible], by the

action of the [illegible] water; [illegible] a

variety of [illegible], pieces of Hindoo

sculpture, [illegible] and remains

of [illegible] of Hindoo temples,

the [illegible] of [illegible]

evidently [illegible] that of the present

day have been found; and at

Baluchi a figure about 4½ feet

in length in deep relief, of

a woman carved in large

masses [illegible], but by some

[illegible] was rescued

for its [illegible] a [illegible]

[illegible] in a building designed

apparently

[illegible] for the especial [illegible]

[illegible] that

[illegible] as and [illegible]

[illegible],

[illegible]

the [illegible] of this country [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible];

[illegible] and [illegible]

[illegible],

[illegible].

[illegible],

[illegible]

[illegible]

[illegible]

[illegible]

[illegible],

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] [[illegible] Say [illegible] P. 159

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible],

[illegible]

[illegible],

[illegible]

[illegible]

[illegible]

[illegible] the [illegible] of

[illegible]

[illegible] passes the drain the Clunn [illegible] with other [illegible] [illegible] it would [illegible] would be [illegible], [illegible] the above [illegible] to [illegible] the [illegible] trouble [illegible] a cut ~~[illegible]~~ be made connecting that [illegible] with the [illegible] drainage.

[illegible] Clunn the drainage [illegible] at the distance [illegible] miles from [illegible] at [illegible] [illegible] the [illegible] the villages [illegible] and [illegible] approaching the [illegible] [illegible] a quarter of a mile [illegible] the [illegible]; [illegible] the East, passing [illegible] a distance of 2 miles [illegible]; [illegible] [illegible] [illegible] which [illegible] the East and [illegible] of drainage [illegible] [illegible] described [illegible] at the village of [illegible] situated about a mile to the [illegible] of the Canal at its [illegible] mile [illegible] tolerably well defined [illegible] the drainage passes [illegible] the village [illegible] its right, ~~[illegible]~~ near the village of [illegible] joins a [illegible] with [illegible]

[illegible]

[illegible] is called the [illegible] the [illegible] the altitude of [illegible] about 1 mile east of [illegible] [illegible] ova, [illegible] to [illegible] the two [illegible] [illegible] described [illegible] the [illegible] separates [illegible] [illegible] and [illegible]ova; the walls [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] beneath.

[illegible] [illegible] [illegible] under the [illegible] [illegible], passes [illegible] [illegible] easterly direction, parallel to the course of the [illegible], and at a distance of about 3 miles [illegible] it; the depression of ground [illegible] increases with [illegible] rapidity as it advances, and in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] 55 [illegible] 3 [illegible] 30 feet [illegible], the [illegible] [illegible] [illegible] 30 [illegible] [illegible] 130 feet [illegible]; the [illegible] [illegible] [illegible] [illegible] [illegible], after [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible], thence, at a point [illegible] the 115th [illegible] where the [illegible] [illegible] [illegible] [illegible] a narrow [illegible] hollow

below into the Pandoo at [illegible] Kunwara, and at [illegible] similar escapes in the canal; [illegible] which [illegible] the Canal is the eastward in direction towards the [illegible] and its tributaries, the Canal is in consequence carried over a country high and dry, and under these favorable circumstances it reaches the village of Kunwan on the 132nd mile.

Immediately above the Kunwan bridge an Escape [illegible] of 31 feet waterway in 5 openings of 6 feet each, has been built for the purpose of giving an outlet into the Pandoo River; this work is on the same design as those which have gone before it, and the apparatus for the management of the sluices is precisely the same; the width of its tail channel is 30 feet and its length is 3550 feet. The difference of level between the sill of the Escape and the bed of the Pandoo is 11.99 [illegible], or 11.4 feet [illegible]. At Kunwan is a [illegible] head and a main station attached to the Escape.

Throughout the length of the 25 miles above described, the line of Canal passes immediately between the Pandoo and the Esan, the [illegible] in advance of the 106th mile, the course of the Canal having passed away to the south, and the Pandoo having assumed the place of that River in its parallelism and propinquity to

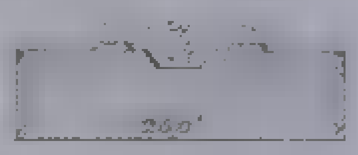
to [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] between the [illegible] [illegible] [illegible] and over ~~a~~ es [illegible] [illegible] [illegible], the narrowest [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] 111 to the 135th mile [illegible] [illegible] to 351 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 1000 [illegible] of the [illegible] [illegible] [illegible] the [illegible] of the River. [illegible]

10th [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 1 99.31 [illegible]

3d [illegible] at [illegible] [illegible] 23.0 [illegible]

[illegible] [illegible] [illegible] [illegible] at the 135th mile is [illegible]

Map XXXVI



a [illegible] of 11 feet [illegible] the [illegible] height [illegible] [illegible] [illegible] [illegible] [illegible] feet.

([illegible] to represent the first 2 miles which have a slope of [illegible] feet [illegible] mile).

[illegible] canal [illegible] made [illegible] [illegible] [illegible] depth [illegible] [illegible] as follows:

100th to 110th mile 7·15
111th to 121st " 11·16
121st to 130th " 7·05
130th to 135th " 7·18

[illegible] accurate [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as [illegible]

[illegible] depth [illegible] [illegible] 3·5 [illegible] maximum [illegible] [illegible] minimum [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] constructed [illegible] [illegible] of [illegible] [illegible] ideas.

1st Bridge at [illegible] [illegible] [illegible] feet roadway with [illegible] [illegible] [illegible] [illegible] [illegible] attached.

2nd Bridge at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] feet [illegible] [illegible] attached.

3rd Bridge at [illegible] [illegible] [illegible] [illegible] with a [illegible] [illegible] attached.

4th Bridge at [illegible] similar

[illegible] [illegible] similar to that at the [illegible], with a 1st class [illegible] attached.

5th Bridge at Comudu [illegible] similar to that at [illegible], with a 1st class [illegible] attached.

6th Bridge at [illegible] [illegible] of [illegible] [illegible] Roadway 16 feet wide. Flat [illegible] [illegible] heads [illegible] a 1st class [illegible] attached.

7th Bridge at Khunnugolu similar to that at Soorkhi, with a 1st class [illegible] attached.

8th Bridge at Atma, similar to that at Soorkhi, with a 1st class [illegible] attached.

9th Bridge at Bawapoor similar to that at Soorkhi, but without [illegible] [illegible] heads [illegible]

10th Bridge at Bidhun [illegible] [illegible] of 25 feet each. The roadway [illegible] [illegible] [illegible] with heads, and a 1st class [illegible] attached.

11th Bridge at Ool[illegible] similar to that at Bidhun, with a 1st class [illegible] attached.

12th Bridge at Munowe similar to that at Bidhun, with a 1st class [illegible] attached.

13th Bridge at [illegible] [illegible] [illegible] [illegible] heads same as at Bidhun. Roadway 20 feet wide. [illegible] [illegible] of 30 feet [illegible] [illegible] and a 1st class [illegible] are attached to these works. —

From

135th Mile to End

From the Station at Kukwan or from the 135th mile, the Cawnpore Branch continues on another length of 35 miles at the termination of which it falls into the Ganges River.

The direction of the line which continues of the same curve as that upon which it reached the Kukwan Station is curved to the south and clear of the [illegible] drainage; at the 139th mile it takes a sweep to the right passing equidistant between the high banks of the Ganges and the Pandoo Rivers ~~(at the 151st mile) near the village of [illegible]~~. From thence on a gradually increasing curve with the high banks of the Ganges still on its left, it crosses the high road between Kalpi and Cawnpore at the village of [illegible], and the Grand Trunk Road near the village of [illegible]; it meets the Cawnpore Cantonment on the boundary that separates it from the City, along this boundary the Canal passes, and after crossing a portion of Cantonment land reaches the lower lands of the Ganges River in a fall of [illegible] feet in a flight of [illegible] locks(?).

The line of Canal throughout the whole of the 35 miles which I am now describing passes over a series of curves, following the intricate drainage which intersects this portion of the Cawnpore District; these curves have in part continued unin-

= terminated(?)

-terrupted[illegible] from the 101st mile downwards, and has generally speaking [illegible] level but with great [illegible], and on as long radii as possible; the general aspect of this portion of the course of the canal will be best understood by referring to Plate IX of the Atlas.

From the 135th mile which is the point upon which this Section commences down to the 146th mile, the channel proceeds uninterruptedly and unimpeded by drainage of any kind; it passes within a quarter of a mile of the [illegible] which lies to the East opposite the 138th and 139th miles, running parallel and at an equal distance as far as the village of Kumalpur. At the 146th mile, near the villages of Mirza [illegible] Rawada and Bahurgunj, the line crosses a small ~~[illegible]~~ [illegible] connected with the [illegible] drainage by this intersection [illegible] the drainage [illegible] about one mile in length is cut off, this will be thrown into the [illegible] by a cut* made [illegible] from the right of the canal at that point; this amount of drainage, however, so cut off is very [illegible], and it is [illegible] whether any steps will be required for its relief, this is one amongst others upon which I should be disinclined to spend money until [illegible] of a few years proved the necessity of it.

From

* This cut has since been [illegible] is 5 feet wide [illegible] cut through the [illegible] ground that [illegible] the [illegible] —

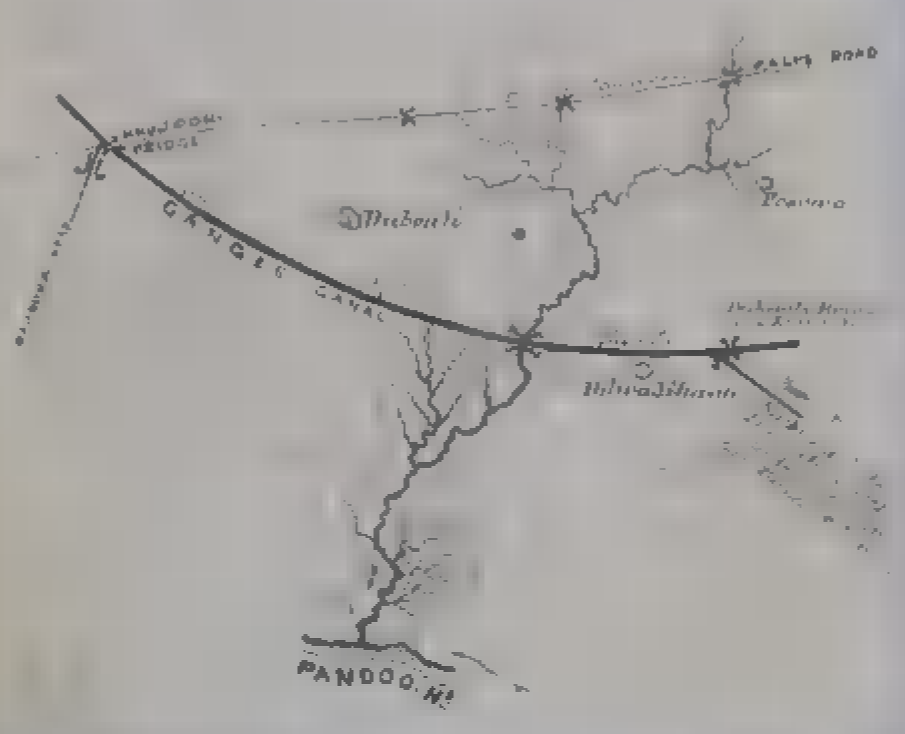
From the [illegible] to the 18th mile the line passes over a [illegible] country [illegible] the drainage [illegible] it [illegible] the [illegible] of the [illegible] [illegible] at [illegible] it [illegible] at last [illegible] when [illegible] with the [illegible], this [illegible] is [illegible] by a set of works combining the passage of the [illegible] by an aqueduct with a free waterway for its drainage, and a series of outlets, or escapes from the Canal; these works are in fact, the Regulating Head of the Canal in its approach to the Ganges, and are the commencement of a series of works connected with the Escape into the River, and with the Irrigation of the country which we leave on the right, and which terminates at the Junction of the Pandoo with the Ganges ~~[illegible]~~.

The [illegible] drainage which is crossed by the works above alluded to, is of more [illegible] consideration than that without making a great and a very unusual detour, the Canal line could not have been carried in any other way than it has been. The [illegible] is [illegible] sufficient [illegible] to the demands [illegible] the Cawnpore works is called for, for Escape in their neighbourhood, and the position of the [illegible] with reference to its proximity to the Pandoo, and the capacity of both for the purposes of drain-ing

-ing of the Escape water un-
circumstances in any way
favourable to the uses for which
they are required.

The following Diagram
will explain the relative posi-
tions of the canal, the Rutdoo,
and the country with which
we come in contact in the
neighbourhood of Dubouli

Diag. XXXVII



The extent of country
lying on the left of the canal,
the drainage of which comes under the in-
fluence of the Dubouli drain-
age, does not exceed 1 square
mile, its boundaries are well
defined, and the waterway for
its drainage, consisting of 3
passages equal in breadth to
6 feet each, which pass under
the canal, will be quite suf-
ficient for its relief. The Escape
into the Rutdoo channel con-
sists of 6 waterways of 6 feet
each, 3 on each side of the
canal, and so arranged that
the escape water shall fall
upon the lower levels under
every

[illegible] advantage for the rapid passing [illegible] of the water. The [illegible] [illegible] the bed of the [illegible], and [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] 6½ feet, [illegible] [illegible] [illegible] [illegible] [illegible] 2 ft. 10 [illegible] the [illegible] [illegible] [illegible] passage [illegible] of the Pandoo River [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 12.55 ft. [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] will [illegible] [illegible] out [illegible] width [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] drainage and escape water.

Immediately in advance of the [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] village, to [illegible] [illegible] a regulating [illegible] [illegible] at a point [illegible] the [illegible] of a Rajbuha, [illegible] 16 feet in width [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], the [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] it [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] towards the works at

Cawnpore

Cawnpore [illegible]
[illegible]
[illegible]
[illegible]
[illegible] as
[illegible]
[illegible]
[illegible]
[illegible]
the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Cawnpore [illegible]

[illegible] works and at the [illegible] Canal [illegible] of the village of Dunnapoor [illegible] the Grand Trunk Road [illegible] the bridge at this point is with-out [illegible] beams, and is built on a skew at an angle of 65 degrees. the [illegible] of the [illegible] [illegible] on a [illegible] [illegible] [illegible], and [illegible] [illegible] [illegible] [illegible] Dunnapoor Bridge [illegible]

At the distance of 800 feet in advance of the Grand Trunk and the Bridge at Dunnapoor [illegible] in passing a [illegible]
[illegible]

[illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] boundary; [illegible] this
boundary [illegible] for a [illegible] distance
separating the [illegible] [illegible] part
[illegible], [illegible] [illegible] [illegible] proceeds
[illegible] [illegible] [illegible] [illegible] portion
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible], [illegible] [illegible] [illegible] straight
[illegible] [illegible] [illegible] the "Cruise
wey" [illegible] [illegible] bridge, [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] it takes a
[illegible] [illegible] to the left, and by
a series of [illegible] [illegible] [illegible] [illegible],
[illegible] the [illegible] of the [illegible]
[illegible].

It is a [illegible] [illegible] fea-
[illegible] [illegible] [illegible] [illegible] the ground
[illegible] [illegible] approach [illegible] [illegible] at least
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
to Dr. Cook, that there should be
a gradual rise [illegible] [illegible]; this
[illegible] [illegible] [illegible] the left bank
of the [illegible], [illegible] [illegible] the
[illegible] bank [illegible] [illegible] [illegible] at all
~~the points~~ [illegible] [illegible] the lines
[illegible] have been [illegible]; it
was [illegible] [illegible] [illegible] in the
[illegible] [illegible] [illegible] the lines
of [illegible] [illegible] [illegible] originally
[illegible] towards the [illegible]
both at [illegible] and [illegible] [illegible],
and [illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] and it approached the
bank [illegible] the [illegible] [illegible], was
the great cause of the [illegible]
attendant upon [illegible] [illegible]
[illegible] [illegible] [illegible] which I
[illegible] [illegible] [illegible], [illegible] [illegible]

-[illegible]

-cal land [illegible]
marked as it was [illegible]
and in [illegible]
[illegible] the [illegible]
throughout the [illegible]
[illegible]
depth, [illegible] 10 to
11 feet. [illegible]
that [illegible]
[illegible] was
excavation, the depth of dredging
on the line which passes through
[illegible] was [illegible] an average of
10 feet, through a soil that was
hard and [illegible] at the
surface, but sandy below, it
became [illegible] necessary to
design [illegible] that
would maintain the [illegible]
[illegible] prevent the
falling in of slopes, and retain
the water within accurate and
well defined limits; it was also
a matter of consideration, to ren-
-der this portion of the canal
which was so directly connected
with a large and populous
[illegible] as well as
useful, to [illegible] the bridges
and works [illegible]
[illegible] which were necessary
[illegible] the extreme [illegible struck-out word] are
[illegible] simplicity [illegible]
adopted [illegible], to give means
of approach to the water [illegible]
[illegible] stair cases, and to pro-
-vide [illegible] accommo-
-dation to the community in
wharfage and quays for the pur-
-pose of loading and unloading
merchandise

merchandise. An extensive system of [illegible] connected with the [illegible] of the country gives to the [illegible] and [illegible] the [illegible] features in the proposed improvements.

For a perfect understanding of the works which have been [illegible] in the Town of [illegible], Plate **XLIV**, of the Atlas must be consulted. In a general way, however, they consist of a double line of Revetments on an upper and lower level, with bridges for cross communication opposite each main street; these bridges form the canal into a series of bays, which communicate on the upper [illegible] by means of locks; from these the [illegible] continue to the River, each lock having its passage for cross communication and quays for the landing of goods. The [illegible] which face the River has been designed [illegible] [illegible] a flight of steps [illegible] to the right and left of the entrance into the lock chambers, these ghats are backed by [illegible] [illegible], constructed on [illegible] [illegible] and the descent from the upper levels which is gained by a double [illegible] is [illegible] by [illegible] the [illegible] and [illegible] figures [illegible] great [illegible]

and

and [illegible] of this [illegible]
as [illegible] as [illegible]
to [illegible] [illegible]
with the [illegible] of the [illegible],
community; and as its [illegible]
[illegible] of character [illegible]
to [illegible] with the [illegible]
and [illegible] neighborhood ~~[illegible]~~
~~[illegible]~~ a departure from the
usual [illegible]
European travels, which are
perhaps neither so picturesque
nor so well [illegible]
[illegible], as [illegible], may be excusable.

To [illegible] a passage [illegible]
the [illegible] at [illegible]
[illegible] of the [illegible] of the
[illegible]
[illegible]
a good deal of [illegible]
[illegible]
[illegible]
to [illegible]
for which [illegible] it was
[illegible], and the [illegible]
which [illegible] was [illegible] was that
[illegible]
to a [illegible]
[illegible] that it was [illegible]
at [illegible], [illegible]
[illegible]
for [illegible]
been [illegible]. [illegible]
[illegible] was the
[illegible] the [illegible]
[illegible] was assembled for
the [illegible] purpose, and the
[illegible] was [illegible]
[illegible] by the Executive
~~[illegible]~~ [illegible]

[illegible]

no [illegible], the [illegible] [illegible] on the area appropriated [illegible] the line of canal for no buildings of any importance, a mosque which came within the boundary has been allowed to remain, and as much indulgence in this respect as could be allowed with reference to the purpose [illegible] carrying out of the works was uniformly granted. The width of ground between the two lines which were fixed upon as the canal boundaries was determined at 280 feet, and the general design for laying out this ground will be illustrated by the following Diagram, showing a transverse section [illegible] the line [illegible].

Diag: XXXVIII

The canal channel as it will be constructed being entirely [illegible] the space [illegible] within the boundaries [illegible] [illegible] into two esplanades [illegible] equal to 100 feet in width. This [illegible] will be planted [illegible] the [illegible] of [illegible] buildings which it is proposed to lay out in lines parallel to the canal, with facades of uniform street architecture. Rows of mangosteens planted at a distance of [illegible] feet apart

will

will divide the esplanade into a [illegible] road [illegible] [illegible] road [illegible] street [illegible] width [illegible] of the avenues [illegible] foot passengers. I have selected [illegible] [illegible] for this purpose [illegible] these trees, because they are the [illegible] of any [illegible] [illegible] to the [illegible] of the country; I have rejected the [illegible] [illegible] which in the [illegible] District is a tree of the most umbrageous and [illegible] [illegible] [illegible], because it is [illegible] [illegible] planted by the natives in the vicinity of their towns and residences; it is not, moreover, a fruit tree, nor does it produce the [illegible] [illegible] which is so [illegible] to [illegible] [illegible] [illegible].

The design of drainage is shown in the above section. The esplanades slope in a very [illegible] degree towards the [illegible] at the [illegible] of which is a drain which [illegible] not only the rain water that falls on the esplanade, but [illegible] [illegible] fall on the streets [illegible] [illegible] [illegible] [illegible]; these drains are [illegible] by [illegible] [illegible] wells (or [illegible] [illegible] the natives [illegible] [illegible]) which are situated at distances along the drain, the wells [illegible] [illegible] being connected with [illegible] [illegible] channels (as shown in the above section), [illegible] [illegible] the water [illegible] to the canal, [illegible] [illegible]. The [illegible],

or [illegible] (at [illegible] are [illegible]
[illegible]
[illegible]) [illegible]
[illegible] wall [illegible]; they
[illegible] in part and [illegible]
[illegible] may [illegible]
[illegible] across the [illegible]
[illegible] or [illegible]
[illegible]
[illegible]
[illegible] was [illegible]

The numerous inlets from the [illegible] and its neighbourhood, with a [illegible] of water into the canal below the [illegible], and [illegible] and the [illegible] of the [illegible]; [illegible] this [illegible], a [illegible] with [illegible] was [illegible] constructed in connection with a [illegible] under the name of the "[illegible] nullah" passes [illegible], and ultimately [illegible] the [illegible] nullah. [illegible] manner, and only [illegible] water [illegible] during the rainy season, will [illegible] occasional [illegible], and [illegible] into a well [illegible] channel, kept under proper supervision.

The above description of the works [illegible] will [illegible] give a fair idea of the design upon which they have been constructed; they have occupied a [illegible] [illegible] by [illegible] [illegible]

ter, [illegible] wet [illegible] species of [illegible] and want of ventilation; the means [illegible] the [illegible] of getting rid of the pools and ponds which were within the bounds of the Canal boundaries, but depositing them on others, and of filling and equalizing the ground with the [illegible] Ravines and [illegible] adding [illegible] to the salubrity [illegible] the appearance of these places [illegible] and trees [illegible] spaces [illegible] occupied [illegible] Roads, [illegible] mills, [illegible] have been [illegible] with the [illegible] boats, [illegible] the [illegible] for unloading [illegible] the immediate vicinity of the town facilities [illegible] have been [illegible] introduced into the [illegible] of a thickly populated [illegible] and, perhaps, one of the greatest improvements which the works have led to, is the advantage derived from ventilation by the [illegible] of a central line of [illegible] with the attendant convenience of [illegible]

The military Cantonment of any part the boundaries of which at the present time are of a very irregular description, [illegible] the Agency of the Canal works, is placed on a more compact

[illegible]

-pertaining. I have before pointed out the Canal [illegible] lines of which have been [illegible] it and [illegible] other [illegible] is incon-sistent with the [illegible] of sepa-rating the Town from the military [illegible] the boundary of which, as [illegible] along the edge of the Town which is parallel to, though at some distance from the bank of the Ganges, the Can-tonment lands therefore separate the town from the River by a narrow [illegible] a strip ranging in width from ½ to 1½ miles and extending as far as 3 miles up stream to a point on which the Ordnance Magazine is situated, this long strip of land is occupied by barracks and parade grounds of the different Corps both Euro-pean and native, and as it will be understood from the above description is crossed by the line of the Canal on its approach to the River. The Canal in fact di-vides the Cantonment at a nar-row neck where its width between the Town and the River is three quarters of a mile. The following Diagram which gives an ade-quate representation of the dimensions of the boundaries of the military Cantonment with reference to the Town of Cawnpore, will be suggestive at once, of the facilities which the Canal works offer for re-modelling the Cantonment boundaries, should such be considered at any future

time advisable.

Diag. xxxix.

The alternative which I would propose, and which in fact amounts to [illegible] improving the [illegible] on the [illegible] at the [illegible] straggling nature of the Cantonment, [illegible] [illegible] its present boundaries [illegible] to the Town [illegible]" [illegible] the whole of the troops, [illegible] now quartered on the left, and in [illegible] strip which separates the Town from the River, to the right of the Canal [illegible] the eastern boundary of the Cantonment, and to give up to the Civil authorities the whole of that narrow strip which now separates the Town from the River. By these means the Cantonment would be compact, its police arrangements would be [illegible] better than at present, and its [illegible] with the Town would be [illegible] the [illegible] [illegible] [illegible] [illegible] which the Canal runs. Whether the inconvenience [illegible] over the

the Ditch's from the West to the East, and the transfer of so much Barrack room out for the property would militate against the above arrangement. I am unable to say, it is a great measure, that many of the said barracks and public buildings are now lying on the West of the Canal, because [illegible] in consequence of the reduction of the European force; these Barracks and these buildings are therefore available, and their existence is so much also in favour of the removal of the troops to that side of the Canal. At any rate by reducing the extent of the Cantonments which in consequence of the great reduction of the military force [illegible] is occupied by people utterly unconnected with the [illegible] force present unmanageable length of 6 miles to a more appropriate dimension of 3 (which, moreover, is [illegible] more in accordance with the wants of the Force in its present strength) the Government would in addition to the advantages already enumerated, gain a most desirable accession of [illegible] valuable land, the return from which would repay them over and over again for any changes that might be made in the distribution of public buildings, or in the [illegible] of the [illegible]

The Canal in its passage through the last 25 miles of its course keeps as I have before described

Sig. X P. 305. V. i.

described on the high ridge which separates the Pandoo from the Roon and the Mahanada Rivers, in the early part it runs in near proximity to the Oruni drainage, its direction towards being guided by the course of the Pandoo and by the low land of the Roon which at the villages of Purtabpoor and Nonsowli approach to within 2½ miles of each other. On this high land the canal takes its course leaving the Roon which enters the Ganges to the South of Kutteean and proceeds in a parallel and close to the Pandoo River to the point where it comes in contact with the Dubowli drainage; from thence it takes a line towards Cawnpoor, deviating the course of the Pandoo entirely; the latter River continues towards in a South Easterly direction to the boundary of the Cawnpoor and Futtehpoor Districts, upon which it passes to the north, and joins the Ganges River on the boundary of the Bindkee and Jah Futtehpoor pergunnahs; from the point where the Dubowli drainage enters the Pandoo to the junction of that River with the Ganges, the course of the Pandoo may be estimated as measuring in all its tortuosities, on a length of [illegible] miles: its course is parallel with the Ganges, and the two rivers in their progress from Cawnpoor and to the point of junction enclose a tract of

highly

[illegible] cultivated
highly country of about 25
miles in length by an average
of 8 miles in breadth, or a Super-
ficial area of 200 square miles,
all of which will come under
Irrigation from the Works[?] whose
head at Dubowli.

From the village of Kukwan[?]
to the Town of Cawnpore, the strip
of land between the river and
Pandoo along which the Canal
runs, is variable in breadth, but
it never exceeds 6 miles. The fall
of the surface of the country from
Kukwan to that point on the
high land at Cawnpore from
whence the slope towards the
river commences is 25 inch feet
in a length of 33 miles, or .78 feet
per mile; between that point
and the surface of the Ganges
river, the distance being about
2 miles, the fall is equal to
56.56 feet.

The [illegible] levels at different points
shew the relative levels of the bed
of the Pandoo River with the
country on the left or with the
[illegible] in which the river
and Ganges River [illegible]. –

Kursowli[?] 36th mile. Pandoo
below country where the Canal
crosses – feet 15.39

– 36th mile. Down [illegible] of
the River at 6 miles from
the Canal. – 13.5

Dubowli 65th mile. The bed of the
Pandoo at the junction of
the Dubowli drainage appears
by a cross section taken by
Lieut. Charles Hutchinson[?]
of the Engineers to be only
12.93

1293 feet above the [illegible] of the Ganges river at a point where the Old [illegible] [illegible], and [illegible] [illegible] village [illegible] Jowalapur; immediately at the Junction of the right bank of the Rutmoo with the running [illegible]. —

The bed of the Canal [illegible] at the [illegible] of [illegible] Roorkee [illegible] 921·91 feet above the bed of the [illegible] river at the junction of the Roorkee drainage. —

The Section of the Canal Channel at the point where the Grand Trunk Road crosses the [illegible] near the village of Puthree, a[illegible] was as follows:

[illegible] XL

[illegible]

The height of the banks [illegible] the Canal bed varying [illegible] from 3 to 6 feet [illegible] from the Roorkee works down-wards.

The bed slopes of the Canal [illegible] [illegible] [illegible] a declivity of 1[illegible] [illegible] per mile, and the [illegible] depths of [illegible] [illegible] throughout this Section may be [illegible] as follows: —

135th	to 140th	mile	6·32
140th	to 150th	do	8·20
150th	to 160th	do	9·75
160th	to 170th	do	9·71

The [illegible] from Kutwara [illegible] is of the same [illegible]

(continued)

[illegible] [illegible] and [illegible] before described it to [illegible] the excavations that have taken place in the Cawnpore District; it is only in the deep digging on our approach to the Ganges River, [illegible] we come in contact with ~~the~~ sand.—

The ordinary depth of digging [illegible] as usual from the surface of the land to that of the water [illegible] a maximum equal to 57 feet and [illegible] a minimum equal to 4 feet.

[illegible] the Bridges and Escapes at [illegible] the following works have been constructed:—

1st Bridge at [illegible] of two arches of 20 feet each. Roadway 15 feet wide, with Flats, Rajbuhas and [illegible] roads, and a 2nd Class [illegible] attached.

2nd Bridge at Koondun of 50 feet waterway in 2 arches of 25 feet. Roadway 15 feet [illegible] flats [illegible] attached to this work.

3rd Bridge at [illegible] similar in every respect to that at [illegible], with 2nd Class [illegible] attached.

4th Bridge at Bhosam[?] of 31 feet water way, in 1 arch. Roadway 20 feet wide, with Flats, Rajbuhas and [illegible] roads, also a 2nd Class [illegible] attached.

5th Bridge at [illegible] of 31 feet waterway and 13 feet Roadway, with Flats, Rajbuhas and [illegible] roads, and a 2nd Class [illegible] attached.

6th Bridge at [illegible] similar to that at Rungputtoor with a [illegible] arch [illegible] above

7th Bridge at [illegible] similar to that at Rungputtoor with [illegible] above

8th Bridge at [illegible] similar to that at Rungputtoor with [illegible] above

9th Bridge at [illegible] similar to that at Rungputtoor with a 1[illegible] arch [illegible] above

10th Bridge at [illegible] of 8 feet waterway to [illegible] Roadway 18 feet wide - with Rails [illegible] and Inlet Heads

11th Bridge at [illegible] [illegible] of 3 [illegible] waterway [illegible] 9 feet and Roadway of 20 feet [illegible] and [illegible] [illegible] with a [illegible] arch [illegible]

12th [illegible] at [illegible] with [illegible] of the [illegible] a [illegible] 1 Plate No XLII [illegible]

13th Bridge at [illegible] of 20 feet waterway and 18 feet Roadway with [illegible] in the [illegible] of the [illegible] [illegible]

14th Bridge at [illegible] of [illegible] waterway and [illegible] feet Roadway [illegible] the [illegible] across the road.

15th [illegible] at [illegible]

[illegible] Bridge

2 2

3 2

No. 4. [illegible] Bridge
5. [illegible] Mogul Serai Bridge
6. [illegible] Bridge
7. Bridge [illegible]

[illegible] all these bridges are on the same design as that at [illegible] [illegible] with [illegible] [illegible] piers of [illegible] [illegible]

Blocks of [illegible] each [illegible] [illegible] length.

[illegible] at the [illegible]

Having [illegible] the plan of [illegible] which have been constructed [illegible] the [illegible] [illegible] [illegible] Diagram XVII. Fig. II [illegible] the diversion of supply [illegible] the [illegible] departure at [illegible]. It is [illegible] the present [illegible] this Dia[illegible] as [illegible] actual working out of the project [illegible] accurate [illegible]

The actual head supply of the [illegible] branch [illegible] calculated at [illegible] miles [illegible] is 1610 cubic feet per [illegible] of this supply is calculated as [illegible]

an amount of [illegible] cubic feet per second being allowed for the losses on the [illegible].

Miles [illegible] Total

170 × 8 = 1360 cubic feet per second [illegible]
[illegible]
[illegible]
50 cubic feet additional
for the purpose of
[illegible] supply
[illegible]
[illegible]
[illegible]
[illegible]
100 cubic feet per second
[illegible]
for the purpose
of navigation

[illegible] in the detail above assumed, figures [illegible] stations along [illegible] at different points of the course, the width [illegible] rectangular [illegible] which depths equal to the depth of [illegible] as to convey the [illegible] calculated [illegible] this width is on the first 100 miles gradually reduced to [illegible] to the 168th mile the width is reduced to [illegible] of 1 foot in every [illegible] mile until it arrives at the [illegible] Bridge: [illegible] this measurement it proceeds onwards to the [illegible] at Cawnpore.

The [illegible] of the different Channels on the [illegible] stations above given are as follows: –

[illegible] at	value of R	value of $\frac{1}{6}$	Sectional Area in Sq. feet	V in feet	Discharge Sir Wm's [illegible]
1st [illegible]	6[illegible]	[illegible]			
30th do					
65th do					
100th do					
135th					
[illegible]					

[illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible] [illegible] of the
[illegible] [illegible] [illegible] [illegible] [illegible] pass
of [illegible] [illegible] [illegible] 1.5
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] it [illegible] [illegible] to
the [illegible] [illegible] [illegible]. [illegible]
[illegible] [illegible] [illegible] and [illegible]
the [illegible] of the [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible],
the [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] necessity of
[illegible] [illegible] [illegible] [illegible] ladder
[illegible] [illegible] [illegible] [illegible] means
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] of [illegible] [illegible] [illegible] [illegible]
of [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] with navigation. They
~~[illegible]~~ ^(lead) to [illegible] [illegible] as [illegible]
[illegible] [illegible] [illegible] as the falls
[illegible] [illegible] [illegible] ~~[illegible]~~
~~[illegible]~~ and they ~~[illegible] [illegible]~~ ^(require)
~~[illegible]~~ for their passage by a
[illegible] [illegible] [illegible] in
[illegible] [illegible] [illegible] [illegible] works
[illegible] the [illegible] ~~[illegible]~~ ^(Fran[illegible]) [illegible]
[illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] at the 3rd [illegible]

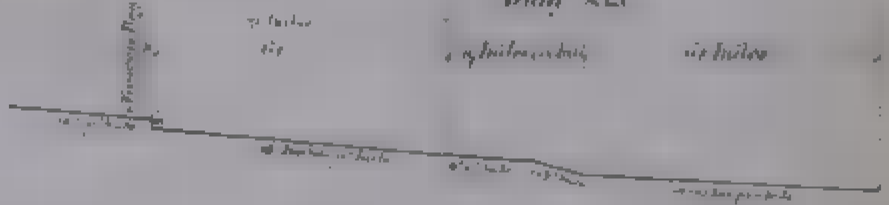
[illegible] positions [illegible] is situated [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] V [illegible] [illegible] 10^{ft} [illegible] [illegible] the 10^{ft} [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Station at	Value of R	Value of $\frac{1}{h}$	Chord of arc [illegible]	V in feet	2nd Division: Minimum	2nd Division: Requisite

We have [illegible] two [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] is equal to 12 [illegible] [illegible] interesting to observe the effects

[illegible] with the deposits [illegible] in the [illegible] of these two depressions. [illegible] the 71st mile [illegible] of the [illegible] 1.95 [illegible] 12 [illegible] [illegible] a [illegible] [illegible] the [illegible] [illegible] to produce a [illegible] up [illegible] deposit [illegible] in the [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] may be [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] about [illegible].

Diag XLI



[illegible] that the [illegible] [illegible] [illegible] [illegible] a [illegible] deposits [illegible] and on the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] adapted [illegible] particular [illegible] the lower [illegible]; and [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the [illegible] [illegible] building [illegible]

Lockage

[illegible] of the [illegible] [illegible] [illegible] with [illegible] [illegible] [illegible] cation [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible], [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] that reduced the [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] parts [illegible] quantity [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] making the [illegible] [illegible] [illegible] [illegible], [illegible] it was [illegible] [illegible] [illegible] [illegible] [illegible] founded [illegible] [illegible] [illegible] with [illegible].

To reduce the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] found it convenient to carry on a ~~[illegible]~~ system

system of gradual reduction of waterway to the bridges corresponding with that ~~of the reduction~~ of the sea-water channel, by this much material was saved, although great additional work has been given to the Executive. It may appear strange that such a saving in time or a saving in [illegible] is contemplated in building a set of bridges whose waterway shall remain on a maximum dimension, of building 10 bridges of 30 feet waterway, instead of 11 bridges ranging from 30 to 16 feet in width; but under the circumstances in which we are placed with regard to establishment, and under our inability to obtain more than perhaps one or two good mistrees (head bricklayers) [illegible] to 100 men with [illegible] superintendence of any de-tached [illegible], I believe, no doubt that 11 bridges built [illegible] on one dimension without any variation in plan or elevation would be completed in a shorter time and at less cheaper, more [illegible] and [illegible] than were the plan and elevation of every one different. In quantity of material however the latter plan is an economical one and it was for the saving in that item ~~[illegible]~~ that the change from my original design was made. The [illegible]

hibit of Bridges with their waterways as explained in my Estimate of 1850, placed in juxtaposition with those actually built by Genl. Bougher, will be explanation of the changes that have taken place in this portion of [illegible] Report.

Bridges done with variations agreeably to Estimate of 1850				Bridges built by Genl. Bougher			
Number of Bridges	Number of Bays	Width of each Bay	Total Water-way	Number of Bridges	Number of Bays	Width of each Bay	Total Water-way
9	3	33	99	7	3	33	99
[illegible]	2	38	76	1	3	32	96
7	3	25	75	1	3	31	93
5	2	33	66	2	3	30	90
12	2	30	60	2	3	29	87
[illegible]	2	25	50	3	3	28	84
6	1	30	30	2	3	27	81
3	1	25	25	3	3	26	78
				2	2	35	70
				2	2	33	66
				2	2	32	64
				2	2	31	62
				8	2	30	60
				11	2	25	50
				6	1	30	30
				2	1	25	25
				9	1	20	20

The design of the buildings is similar to that which has been used in the lower part of the [illegible] Canal [illegible] [illegible] towing path passages [illegible] of the [illegible] and towing path [illegible] Excavated Channels, [illegible] & [illegible] Outlets are attached to every bridge with the few exceptions noted in the detail, and the heads of these

The outlets which are situated immediately above the bridges, are protected by lines of Revetments and steps, the length of which depends upon circumstances; at [illegible] village bridges, these revetments are restricted to [illegible] feet in length; in the vicinity of Bridges connected with high roads with the main lines of cross communication, or with Escape heads, they are prolonged indefinitely [illegible] length; [illegible] revetments [illegible] 350 feet [illegible] all have steps [illegible] on the downstream side of bridges, and as a general rule, the means of approaching the water have been given [illegible] every case, where [illegible] the convenience of the people could in any way be consulted.

The Escape heads [illegible] as nearly as possible at a distance of [illegible] miles apart, and [illegible] frequency [illegible] down to the 88th Mile [illegible] the Canal line, [illegible] are in all cases ~~[illegible]~~ on the up stream side of Bridges also which they are situated and are on the plans represented in plate XXXIX of the Atlas. The sites of these works are at [illegible] Bridge [illegible] and [illegible] Bridge. The [illegible] outlet which passes its water into a [illegible] of the [illegible], being considered as a component part

of

of the [illegible] [illegible] [illegible]
[illegible] [illegible] in the [illegible]
[illegible] [illegible].

I am informed [illegible]
[illegible] that [illegible]
[illegible] the [illegible]
object that I [illegible]
[illegible]
[illegible] that [illegible]
the [illegible]
not [illegible] impracticable. [illegible]
the [illegible] of the Cawnpore
Branch [illegible]
[illegible] supply of water will be
found [illegible] Division.
In the [illegible]
[illegible]
[illegible] regulators the height
of sill has been uniformly main-
tained at 14 inches above the
[illegible] bed. the same height has been retained
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~ to the 60th mile of the Cawnpore branch
to the [illegible] heads at the
Muddunpoor [illegible] the
point [illegible]
through [illegible] to the Sultanpoor
Bridge the [illegible] has been allowed
[illegible] to 16 inches; from the
96th to the 150th mile, at the
Sultanpoor Bridge, the sill has
been raised to [illegible] inches; from
thence to the canal terminus
the sills [illegible]
regulator heads are on the same
level as that of the canal bed.
Small as the supply may be
that this arrangement insures
to the lower divisions, it is a
certain one, and one that cannot
possibly

[illegible] by the inhabitants [illegible] demand for [illegible] Districts, [illegible] the [illegible] the irrigation [illegible] of the ~~[illegible]~~ tails of the long [illegible] mesquite [illegible] supply [illegible] I could issue [illegible] the [illegible] the [illegible] the [illegible] of [illegible] the [illegible]

In addition to the [illegible] arrangements [illegible] to [illegible] the English walls and the [illegible] capacity [illegible] has been [illegible] advanced [illegible] walls might [illegible] in proportion to the increased volume [illegible] the [illegible] heads [illegible] the [illegible] irrigation [illegible] continued throughout the [illegible] season at the 30 [illegible] the Guadalupe [?] [illegible] of the [illegible] from [illegible] continued [illegible] The [illegible]

[illegible]

[illegible]

[illegible] slopes that the [illegible] paration [illegible] alluded to [illegible] with a disfigurement to the general appearance of the [illegible].

The road which is con-structed [illegible]

[illegible]

[illegible] which [illegible] in order to [illegible] the [illegible] ~~[illegible]~~ to the [illegible] in the [illegible] would be [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible] the [illegible] [illegible] [illegible] the superfluous [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] as follows:

Diag: XLII

[illegible] [illegible] position [illegible] which the [illegible] [illegible] [illegible] [illegible] roadway [illegible] [illegible] is elevated to a width of [illegible] of the [illegible] [illegible] [illegible] [illegible] which is formed [illegible] of the [illegible] [illegible], has a slight slope to the [illegible], and the [illegible] water [illegible] [illegible] [illegible] made through the [illegible] at distances of 50 feet apart, the [illegible] [illegible] will enable these drains to be protected from wear and the

outlet

[illegible] [illegible] [illegible],
[illegible] [illegible] [illegible]
are [illegible] [illegible] [illegible]
[illegible] with [illegible]
[illegible]

[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
and planted [illegible] [illegible]
[illegible] to the [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] in the
[illegible] [illegible], [illegible]
[illegible] [illegible], and
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] in the [illegible] [illegible],
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible], and
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
as the [illegible] [illegible] [illegible]
plantation [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible],
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] in the plantations
[illegible] [illegible] [illegible] – [illegible]
[illegible] the [illegible] of mango
trees

trees to which I have just advert-ed as likely to be of such great benefit to the roadway in pro-viding a shade and [illegible] would [illegible] to the banks from the dry and [illegible] of places be maintained as a part of the plantations.

The accommodation for the Establishments and of the Canal Station posts is of same scale as that on the main line, of [illegible] buildings at distances of about 1½ miles apart, with [illegible] buildings at [illegible] of [illegible] [illegible]; the plan of [illegible] would [illegible] be seen in Plates LIV & LV of the Atlas. — The design of all these buildings is uniform as well as the position in which they are placed relatively to the Bridges and turnings of Canal; deviations from this uniformity are required in two instances. The Barrack Houses [illegible] having been built on a mound at some distance from the left bank, and that at [illegible] having been placed on the right bank of the Canal, at a distance from the Bridge, and in a situation somewhat inconvenient for ~~the~~ its pur-poses ~~for which it was intended~~, so that considering the position of this [illegible], that in preference to continuing its repair and maintenance, I would recommend that it be

[illegible]

[illegible] [illegible] [illegible] the Black
Breed [illegible] [illegible] that was
originally intended for it. At
each of the [illegible] [illegible]
high plantation with [illegible]
[illegible], [illegible]
as has been [illegible] on the [illegible]
[illegible] [illegible], as
has been so successfully [illegible]
out [illegible] [illegible]

[illegible] on the Saugor
Branch [illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
a [illegible] 6th [illegible]. Each section
of the [illegible] under the ex-
ecution [illegible] of the [illegible]
[illegible] [illegible] giving a
[illegible] length of 101 miles, and
Lieut. [illegible] Hutchinson of the
Engineers [illegible] [illegible]
of the [illegible] [illegible]
[illegible] of the [illegible] Saugor
On the [illegible] January 1852
Lieut. Hutchinson [illegible] ill health
resigned his situation and pro-
ceeded [illegible] [illegible] to
England and New South Wales
leaving the [illegible] [illegible]
[illegible] [illegible] alone.
[illegible] [illegible] [illegible]
[illegible] up to [illegible] 6th [illegible]
the [illegible] [illegible]
[illegible] [illegible] acc-
ordance, and to place the work
of the Saugor Branch under
Lieut. Robinson [illegible]
[illegible] of the Saugor
Branch have, since the month
of September 1852, been carried on
by

that Officer
~~Lieut. [illegible]~~, who aided by Lieut. [illegible] of Artillery and by Lieut. E. [illegible] [illegible] of the [illegible] the other ~~[illegible]~~ [illegible] ~~[illegible]~~
placed in charge of
~~[illegible]~~
the [illegible] [illegible], during [illegible] [illegible], pushed the [illegible] to a state of completion [illegible] at any time [illegible] anticipated; [illegible] reasons [illegible] [illegible] difficulties [illegible] satisfaction, and allowed the completion of the [illegible] [illegible] ~~[illegible]~~ [illegible] believe that the [illegible] [illegible] will not [illegible] [illegible] the completion [illegible] [illegible] advanced, [illegible] circumstances would admit [illegible] a demand [illegible] bricks which far exceeded the supply furnished from the Brick manufactories. The difficulties of [illegible] bricks [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] allowed to [illegible] [illegible] in all probability quite unavoidable. —

Terminal line,

The Etawah ~~[illegible]~~

The total length of this Branch from the [illegible] Regulator to the Terminus [illegible] is 175 miles. It leaves the Regulator at an angle of 25 degrees corresponding with [illegible]

that at the departure of the [illegible] [illegible] [illegible] and [illegible] the [illegible] of Bridge [illegible] at which it [illegible] [illegible], [illegible] it [illegible] [illegible] [illegible] with [illegible] [illegible], and with the [illegible] of [illegible] [illegible], it proceeds [illegible] in the same [illegible] direction on a [illegible] of [illegible] [illegible], at the point [illegible] at the [illegible] [illegible] it [illegible] [illegible] to the right [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] position [illegible] the [illegible] [illegible] [illegible] [illegible] from the 116th [illegible] line [illegible]. At this point [illegible] [illegible] [illegible] to the right [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] about the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] almost [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] passing [illegible] the [illegible] of the [illegible] [illegible] the [illegible] [illegible] at the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible]. —

From the above general description it will be understood that the [illegible] ~~[illegible]~~ [illegible] through-out

Fig. Y. P. 321 —

-ous it [illegible] course [illegible]
[illegible] [illegible] de [illegible],
keeping as much as possible
out of the influence of the tub-
-ulations and arrangement which
[illegible] with it. ~~[illegible]~~
~~[illegible]~~ The [illegible] [illegible], the
walls [illegible] by [illegible] the [illegible]
[illegible] [illegible] and [illegible] [illegible]
of [illegible], throughout its whole
[illegible] as [illegible] a [illegible]
direction [illegible] the [illegible] [illegible] that
[illegible] [illegible] foundation [illegible]
[illegible] as [illegible] [illegible]
[illegible] [illegible] by the [illegible],
[illegible] [illegible] the [illegible] and
the [illegible] [illegible] [illegible] course
as [illegible] [illegible] out,
as the position [illegible] [illegible]
[illegible] would admit of.—
The [illegible] [illegible] [illegible] then
[illegible] [illegible] was only touched
upon [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] has
[illegible] [illegible] the doubt [illegible]
of how, and which [illegible]
[illegible] [illegible] by the [illegible]
[illegible], [illegible] [illegible].
[illegible] [illegible] at [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible]
[illegible] with the [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible], [illegible]
[illegible] having certain
points [illegible], [illegible] of no practi-
-cal importance.
In the [illegible] [illegible] of
1854,

1856 [illegible]

[illegible]

was dispatched [illegible] upon the

[illegible]

[illegible] He was

[illegible]

found [illegible]

[illegible]

[illegible]

from this [illegible]

[illegible]

[illegible]

[illegible] the [illegible]

as [illegible]

upon [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] 1845 [illegible]

out [illegible]

[illegible]

[illegible] and the [illegible]

which they [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

had [illegible]

of [illegible]

[illegible]

[illegible]

[illegible] upon [illegible] the [illegible]

the [illegible] between the [illegible] and the [illegible] in all its intricacies of communications, [illegible] the position of the [illegible] [illegible]; and [illegible] time [illegible] the [illegible] distances [illegible] the lines [illegible] them with the [illegible], a [illegible] out a course [illegible] which [illegible] itself [illegible] [illegible] alignment, runs [illegible] as possible in the [illegible].

[illegible] immediately into the [illegible] details of [illegible] [illegible] led to [illegible] dispositions, [illegible] [illegible] been [illegible] out [illegible], and [illegible] from the [illegible] of the [illegible] at the [illegible] of the [illegible] [illegible] [illegible] to have this [illegible] [illegible] between the [illegible] and the [illegible] which the [illegible] [illegible]. The [illegible] passed through the [illegible] [illegible]-tion of the [illegible] [illegible] that [illegible] the [illegible] the [illegible] bounded by the [illegible] and [illegible], [illegible] by which it is both approached

from the bridges above the upper
by turning the road, [illegible]
and [illegible] by lines of
water courses [illegible]
running [illegible] .

It is to be understood
[illegible]
the [illegible]
that the [illegible] fact
of [illegible] were completed previously to
the commencement of [illegible]
Main & Canyon Terminal lines
[illegible]
[illegible] was
[illegible]
the year 1869, [illegible]
[illegible] 1867
that [illegible] and that
[illegible]
[illegible] building
[illegible]
[illegible]
[illegible] but
the [illegible]
at [illegible] allowance
[illegible] the Canal
[illegible] a circumstance that
will account for this [illegible]
state of [illegible] at the present
[illegible] the works.

[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the Maxwell
[illegible] with the
[illegible]
[illegible]
[illegible] and the [illegible]
[illegible] the [illegible]
[illegible] . -

In assigning the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] commanders, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at that particular point, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] advantage [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ best [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ advert to [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] and ~~[illegible]~~ [illegible] [illegible] [illegible], that [illegible], to the [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at [illegible] [illegible] [illegible] in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] its [illegible] [illegible] [illegible] [illegible] that of the [illegible]. [illegible] [illegible]

[illegible]

doubt that the determination of the alignment will prove to be correct, and that the [illegible] about [illegible] will pass off [illegible] abundance of flood water [illegible] - The [illegible] diagram [illegible], will place the [illegible] of the [illegible] features of this [illegible] before the reader; it gives both the Cawnpore and Etawah [illegible] in connection with the drainage of the [illegible] and [illegible]

Diag: XLIII

The [illegible] points A B and C [illegible] along [illegible] to [illegible] ~~for~~ the [illegible] [illegible] [illegible] falls to that [illegible] naturally situated as having the two-fold recommendation of being well suited for the site of the necessary [illegible] & admitting at the same time [illegible] giving favorable [illegible] to the Terminal lines [illegible]

~~[illegible]~~

[illegible] ~~[illegible]~~ [illegible] [illegible]

~~[illegible]~~

[illegible] ~~[illegible]~~

[illegible] ~~[illegible]~~

~~posterior proposals required~~: the valuer in fact any where the lands marked B and C; as that from the point A would have thrown the Canal in contact with the hollows and pits [illegible] with [illegible] of the Bijapur fort. Between the positions of B and C as sites for public buildings there would be no question that the preference should be given to B ~~was the proper site~~, and as the results of our levelling operations had shewn sufficiently clearly that the probable drainage was connected with the Canal there would be no doubt that preferable as it was as a site for a public station, it was still more so as that for the needs of the [illegible] [illegible] by being separated at this point would have the least possible connection with the town drainage of the [illegible]

The Canal [illegible] thence passes [illegible] to the west, and proceeds onwards touching the heads of the drainage [illegible] with [illegible] proper, in the neighbourhood of the Fort of [illegible], the contact is very slight, occurring at the [illegible] [illegible] [illegible] at the [illegible] [illegible] the [illegible] of [illegible]; the [illegible] [illegible] flat throughout, [illegible] so that on the right of the Canal, and passes [illegible] [illegible] which lies at a distance of half a mile [illegible]

by winding over tracts of ~~[illegible]~~ waste
and uncultivated land, the
whole of which throws its
drainage into the [illegible]
River. So far as the 8th m.
[illegible] the line of Canal is
[illegible] a bearing almost due
South, from thence, however, it
takes [illegible] to [illegible] proceed-
ing onwards in a South easterly
direction running parallel to
the [illegible] as well as to the
[illegible]; at the
10th [illegible] the Canal comes in
contact with a [illegible] in the
neighbourhood of the village of
[illegible], and here it passes under
the [illegible] of [illegible]
[illegible], and with little
interference with drainage; at
the 12th mile another nullah but
small, ~~[illegible]~~ as compared
with that at [illegible], is crossed
under similar circumstances;
the [illegible] in fact at the above
two points is [illegible] ~~[illegible]~~ a
[illegible] that passes
into the [illegible] under the
Town of [illegible]. In its
onward course, and between
the 17th and 23rd miles, or between
the villages of [illegible] and
[illegible], the Canal crosses
the [illegible] of [illegible] or
hollows [illegible] is also con-
nected with the [illegible]
nullah. Opposite the village
of [illegible] which lies on the
right of the line these hollows
extend to a distance of about a
mile

mile, and as far as the village
of Ladri which lies equidistantly
between the Canal and the Hinde
River. The whole of this series
consists of straggling lines of
low ground, which appear to
be connected with Sheels or deep
ponds lying under Pilkhutra
and the village of Noch, the
latter hollow being again con-
-nected with ~~another series~~
~~of~~ drainage which passes off
to the Seyngoor, by the Towns
of Mustafabad and Surana
~~which are situated~~ considerably
to the East and opposite the
40th and 56th miles of the
course of the Canal. The portion
of the low land however which
is thus cut off from the drainage
leading to the Seyngoor, will
by artificial Cuts be connected
with the course of the Hinde,
and by these means be as ef-
-fectually drained as they would
be otherwise. From Pilkhutra
the line turns slightly to the
left sweeping round by the
Villages of Keyrana and Surana
between which it passes to the
village of Loonai, from whence
it continues on a bearing sim-
-ilar to that on which it arrived
at Pilkhutra; the sweep above
alluded to, enables the Canal to
pass the heads of the Seyngoor
drainage which run up to
the East of Ana, and its neigh-
-bourhood and it passes between
this and the Kirsyra and
Much further

Muhowutpur hollows which fall into the Rinde, with the slightest possible interference with the slope of either of the Rivers; the watershed is in fact most closely followed on all this line, and with the exception of an intersected portion of low land connected with the Seyngoor, which lies between the 29th and 31½ miles immediately on the approach to Oonaie, the Canal passes over high and more or less cultivated; the portion of hollow which has been thus cut off will it is supposed be relieved by a Cut into the Rinde which lies within a distance of a mile and a mile and a half from it; it is naturally connected with a system of drainage which stretches over the country between Awa and the canal, and which passes off to the Seyngoor by the Mustafabad line of nullah before alluded to.—

The breadth of country between the Rinde and Seyngoor upon which the Canal takes its course, expands as it approaches the head of Awa; on its leaving Nanoon and at the [illegible] [illegible] and Tinuj the distance between the two Rivers does not exceed 5 miles, at the 31st mile and on a cross section at Awa, the distance has increased to 12½; the watershed lies close upon the right bank

of the Gunda upon which the Canal runs, at a distance of about 2½ miles from that River. The slope of the surface of the Country from [illegible] to the village of [illegible], at the 31st Mile, is [illegible] 86 feet averaging 1.9 feet per mile, and the relative position of the beds of the Gunda and Seyngoor [illegible] each other [illegible] well be understood from the following table. This table has been deduced from the sheets of levels taken by Mr Dowsworth, and as it includes the [illegible], (a River with which the main Canal [illegible] in connection, in its passage through the [illegible] District) and the Summit [illegible] at the point where the [illegible] joins it, the relative levels of each will be interesting.

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	ft	ft	ft	ft	ft	ft	ft	feet
Crossing East of Bijnour? 10th mile	–	3.36	–	–	–	–	–	–
— Do — Bussaya 15th mile	–	5.60	–	–	–	–	22.[illegible]	–
— Do — Patna 20th mile	–	7.7[illegible]	–	–	–	–	35.25	–
— Do — [illegible] 25th mile	–	5.09	–	–	–	–	44.05	–
— Do — Awa 30th mile	0.51	7.58	4.70	5.55	[illegible]	4.15	71.3	71.3 [illegible]

With reference to this [illegible] I may observe that Mr Dowsworth appears to have taken the [illegible] line of [illegible] and [illegible] up [illegible] the immediate north [illegible] of Awa, as [illegible]

[illegible]

Rinde River whereas the main and these shallows are in fact as I have before shown, the head of a line which runs by the Town of Punstufabad into the Keyngoor. Lieut Whitings levels taken on a cross section between the Awa hollows and the Rinde, the distance being 2½ Miles, give the following results, using the figures of Lt Whitings series. The site of Lieut Whitings Station at Awa must have been close upon that which was taken up by Mr Dodsworth

Awa station 3,0'49

Bed of Rinde 3,0'57

and the results as showing that there is only a difference of 0.08 is curious. It is very characteristic however of the profile of the country connected with the heads of these rivers, and of the difficulties that attend upon Canal Engineering when ~~this~~ they ~~having to~~ be dealt with ~~them~~.

Nothing could have been more natural than the conclusion which Mr Dodsworth fell, and it is possible that had he extended his cross section in prolongation of the line upon which he was working, and had come upon the Rinde itself, he would have considered that he had come in contact with the Esun River. The people of the country lying between the Awa hollow and the Rinde, and across

which

[illegible] the [illegible] of Canal passes, is shewn in the following Diagram. -

Diag: XLIV

The point at which Mr. Dawson's Cross Section on Awa [illegible] the Jumna River at its junction with the [illegible] River is about 2½ miles below the [illegible] at Agra ~~and at the junction with the~~ ~~[illegible] within [illegible] it~~, the levels [illegible] the surface of the water of the Jumna in the month of [illegible] [illegible] to the levels of the different points immediately connected with the bases of the [illegible], are those of the ~~[illegible] added to this datum in the [illegible] the [illegible] [illegible] of [illegible]~~ [illegible] which the Cross Section [illegible] in contact throughout the whole line between the Rinde and the Jumna, the maximum depression of the surface does not exceed [illegible] feet and that only in very short distances. -

It will be observed from the levels above given, that the course of the Rinde is in a [illegible] level than that of the [illegible], which [illegible] [illegible] to the Rinde [illegible] in the same way that the [illegible] does as described in a former paragraph. The [illegible] of the [illegible] however as it will be understood from what has gone before, take their rise

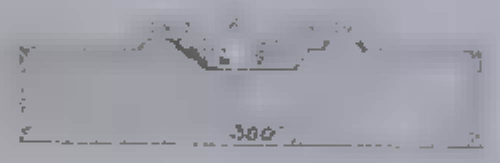
rise on a [illegible] elevation [illegible] higher level than that of the Rinde [illegible] in the [illegible] those of the Rinde lie on a higher level [illegible] than those of [illegible] Eastern [illegible]

[illegible] section of the Canal [illegible] at the 30th mile is as follows:

Diag: XLV.

Section at the 30th mile

[illegible]



[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water [illegible] [illegible]

The [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] series of 15 [illegible] per mile.

The [illegible] with regard to [illegible] [illegible] [illegible] [illegible] is [illegible] [illegible] [illegible] that of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] that of the top [illegible] [illegible] 10 feet.

The [illegible] depth to which [illegible] has been carried [illegible] the [illegible] [illegible] is as follows:–

From 1st to 10th mile			6·30 ft
10th	"	20th "	5·17 "
20th	"	30th "	7·13

[illegible] is [illegible] and [illegible] [illegible], [illegible] occasionally [illegible] with [illegible] the [illegible] to which [illegible] [illegible] [illegible] in [illegible] large quantities [illegible]

[illegible]

[illegible] alluvial [illegible] in the [illegible] District, is prevalent, particularly so in the plains in the neighbourhood of [illegible] and [illegible]; in this respect the soil appears favorable to [illegible] in absorbent quality, and [illegible] is well adapted to the [illegible] of water.

The depth [illegible] in [illegible] from the surface [illegible] to the [illegible] of the water [illegible] the

Left of the Canal Line		Right of the Canal Line	
Maximum	29 feet	Maximum	78 feet
Minimum	13 "	Minimum	15 "

[illegible] [illegible] is [illegible] [illegible] on the above section of the Canal [illegible]

1st Bridge at [illegible] 3 arches of 33 feet [illegible] 18 feet roadway with [illegible] and [illegible], and a 2nd Class Chokee attached.

2nd Bridge at [illegible] similar to that at [illegible] with a 2nd Class Chokee attached.

3rd Bridge at [illegible] similar to that at [illegible] with a 2nd Class Chokee attached.

4th Bridge at [illegible] 3 arches of 30 feet span 18 feet roadway with [illegible] and [illegible] heads, and a 1st Class Chokee attached.

5th Bridge at [illegible] similar to that at [illegible] with a 2nd Class Chokee attached.

6th Bridge at [illegible] similar to that at [illegible] with a 2nd Class Chokee attached.

7th Bridge at [illegible] similar to that at [illegible] with a 2nd Class Chokee attached.

[illegible]

8th Bridge at Pil[illegible] [illegible] at [illegible] with a [illegible] attached.

9th Bridge at [illegible] [illegible] at [illegible] with a [illegible] attached.

10th Bridge at [illegible] [illegible] attached.

11th Bridge at [illegible] [illegible]

12th Bridge at [illegible] [illegible]

2nd [illegible]

From the 30th we continue our course as far as the 65th mile or to the village of [illegible] at which the Canal changes its direction to the right, and this [illegible] the parallelism as well as the propinquity to the [illegible] Branch. —   30th to 65th mile

The direction of the course of the Canal on leaving the [illegible] bridge is South East, and it reaches [illegible] by a gentle curve, on a bearing almost due east; it keeps to the high land near the [illegible], to which it runs parallel and at a distance of about [illegible] miles.

The breadth of country between the [illegible] and [illegible] is about [illegible] miles, in the neighbourhood of [illegible] and [illegible] at the 65th mile the width has gradually diminished

the mile, the drainage towards the [illegible] running in many places close up to the edge of the Bluffs, adjoining the right of Rue, is the watershed. –

I may here observe that from the [illegible] aforesaid, the [illegible] from a [illegible] [illegible] [illegible] [illegible] to [illegible] the [illegible] at [illegible] as [illegible] point [illegible] separate [illegible], passing [illegible] the [illegible] and [illegible] Districts, [illegible] proceeding on towards [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] is $5\frac{1}{2}$ miles, the [illegible] distance [illegible] at the point [illegible] [illegible] [illegible] [illegible] $\frac{3}{4}$ miles apart. The [illegible] [illegible] runs [illegible] although [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] by the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible], [illegible] a [illegible] [illegible] of 300 [illegible] miles; both the [illegible] [illegible] [illegible] run so closely upon the natural water [illegible] of the [illegible] that with the [illegible] [illegible] of that portion [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] natural boundaries [illegible] and [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] of [illegible], may [illegible] [illegible]

is sufficiently convenient to enable us to [illegible] the actual [illegible] of [illegible] that [illegible] to [illegible] at [illegible] that [illegible] the [illegible] but [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible] hereafter [illegible] [illegible] [illegible] [illegible] [illegible] purposes; ~~[illegible] [illegible] [illegible]~~.

In taking up the details of [illegible] [illegible] phases [illegible] At the [illegible] [illegible] 3[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ connected with the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] -[illegible]

[illegible] of the beautiful passing
[illegible] with a large
[illegible] to the south of
that village [illegible]
[illegible] River,
[illegible] the
[illegible] from the 56th to the 71st
mile [illegible] a beautiful
[illegible] altogether
[illegible]
[illegible] with the
[illegible]
[illegible] the town of Muglan
[illegible] passing by the
village of Pudrut, [illegible]
the [illegible] at this point is

201 [illegible] above
651 [illegible] above
1053 [illegible]
[illegible]

[illegible]
[illegible]
passing [illegible]
[illegible]
[illegible]
of the Station [illegible] of the
[illegible]
[illegible]
[illegible]
[illegible]
it [illegible] village of Fulteh
[illegible] 83rd mile
of this point, as well as at
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~ [illegible] the same [illegible]
[illegible]
[illegible]

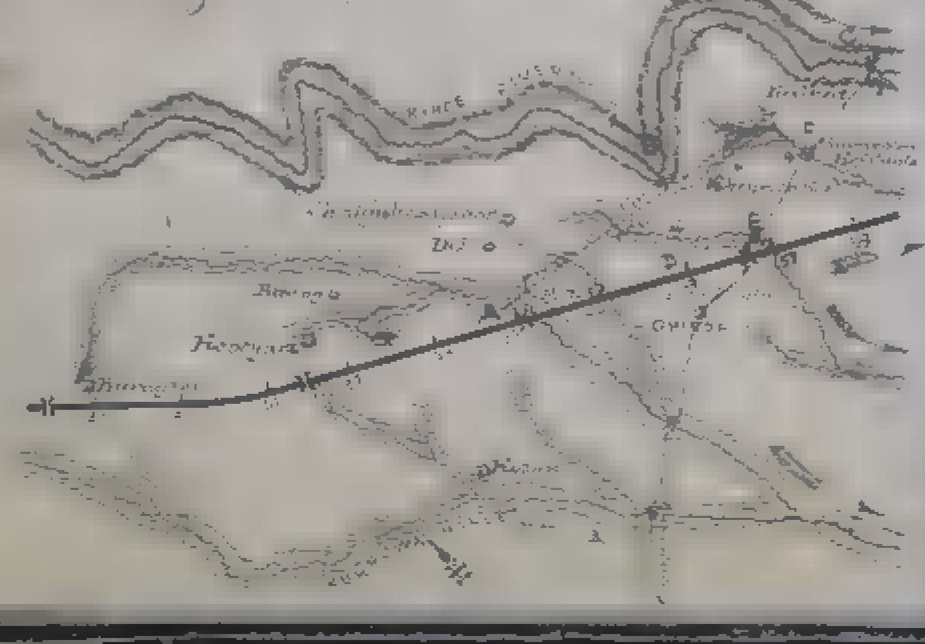
At 56th [illegible] drainage which [illegible] with the [illegible] joins the [illegible] at [illegible], at the 68th mile [illegible] drainage [illegible]

1st Line, or that which is [illegible] by the Canal at the 23rd Mile, rises in the vicinity of the village of [illegible] again; it runs for about 2 miles to the [illegible] receiving in its course (which may be [illegible] at the [illegible] 2) the drainage from the country in the [illegible] of Birnog Koorya[illegible], and crossing the Canal at the village [illegible] Sultan Shan [illegible]

The 2nd Line, or that at the 24th Mile, rises in the vicinity of Shahjuhanpore and [illegible], villages situated at 1½ miles from the point where the Canal crosses it.

The 3rd [illegible] at the 25th Mile rises in the same part of the country as that [illegible] its course before it [illegible] the Canal is 3 miles in length. The [illegible] of this [illegible] may be [illegible] by the [illegible] of a [illegible] with the [illegible] at the 25th Mile; the width of this watercourse is 3 feet. The following [illegible] will [illegible] the above description more intelligible.

Diag: XLVI



according to the levels of the Tables [illegible], the levels of the different points [illegible] above are as follows:

A	398·63
B	401·94
C	405·85
D	399·17
E	399·55
F	399·09

A cut made from A to the Hindun [illegible] at C will have a total fall of 398·63 – 405·85 or 7·22 feet, or as the length of cut is 4½ miles, the slope of the bed would be equal to 1·6 feet per mile, it is proposed to make the [illegible] [illegible] to extend so as to give a free [illegible] passage [illegible] [illegible] ~~[illegible]~~ [illegible] ~~[illegible]~~ [illegible] along the left bank [illegible] with [illegible] [illegible]. At the 61st Mile the ~~line to~~ [illegible] made by the letter F in the above diagram crosses the Canal [illegible] with another [illegible] of the [illegible] which joins [illegible] into the [illegible] of [illegible]; the [illegible] to this line, which [illegible] the [illegible] [illegible] [illegible] of a large [illegible] under the two [illegible] of Khyrea [illegible] [illegible] Nugla, and situated on the west [illegible] between the Grand Trunk Road and the Hindun [illegible] [illegible] Khyrea [illegible] to the point where the canal intersects the drainage at the 61st mile, the distance is 3½ miles, a second cut will be required to

to carry away the water of the
[illegible] to the [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] to [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
Oodkerk and [illegible], all [illegible]
with [illegible] [illegible] drainages are
left [illegible] [illegible] [illegible] [illegible],
with the Dagaon, which [illegible]
[illegible] [illegible] [illegible] a valley
under the [illegible] [illegible]
the canal [illegible] [illegible] upon
[illegible] [illegible] [illegible] with the
drainage [illegible] [illegible] [illegible] [illegible],
as [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible].

[illegible] Station
and attached to the Bridge
over which the [illegible] road be-
tween [illegible] and [illegible]
mosses, is [illegible] with the
Dagaon; it consists of a water
[illegible] of 30 feet, divided into 5
bays of 6 feet each, [illegible]
a [illegible] [illegible] [illegible] [illegible]
[illegible], and is connected to
the Bridge [illegible] [illegible] of [illegible]
(Atlas Plate XLV). The distance
between the canal at the [illegible]
and the Dagaon River is
[illegible] miles and the difference of
level between the sill of the sluice
[illegible] and the bed of the
river is equal to 10·5 or 2·9
feet per mile, the [illegible] of
the canal being 25 feet in width.
Between the [illegible] Bridge and

Fig 3 - P. 337

At 6th mile [illegible] was attained to the Bridges on the [illegible] which will in all probability be connected with a main line of irrigation which will be divided into 2 Branches, one for the purpose of irrigating the country between the [illegible] and the [illegible] rivers, and the other for the irrigation of a similarly situated, although smaller tract lying between the [illegible] and [illegible], to this [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] slope of the [illegible] of the country from the 50th to the 65th mile is equal to 38.18 or on an average [illegible] per mile; at this [illegible] we come in contact with a sudden change in the level of the country which appears to me to be one of the characteristic and marked features of this Doab, when approaching the heads of [illegible] [illegible] [illegible]; [illegible] [illegible] to this change of slope [illegible] [illegible] [illegible] the country in the neighbourhood of [illegible] and [illegible] at and near where the [illegible], [illegible] and [illegible] take their origin; it is [illegible] in the [illegible] Canal by the [illegible] and [illegible] falls, in which the sudden variation of level is overcome by descents of five feet each, and at the [illegible] Bridge it is represented by a

drop of 9 feet: the Surveyor in fact in his progress with the levelling instrument finds that he has suddenly made a descent, and that the profile rests entirely upon a new and different series*

In a general aspect the Country lying between the Ganges and Jumna has a surface with [illegible] slopes diminishing as it approaches the junction of the two Rivers at Allahabad; it is separated into series of well defined and sudden changes of levels, giving the profile the appearance of steppes each of which is marked by its own peculiar drainage, and each of which defines, in a manner the most unmistakeable, the position of the watershed. -

At

*This complete change in the series of level to which I have adverted in the text, must not be confounded with local depressions which are occasionally met with under circumstances which are very liable to mislead. A good example of such depressions extending over wide surfaces is shewn on the tract of country between the Jumna and Ganges [illegible] the Town of Futtehpoor; in the [illegible] [illegible] and in the space of 6 miles my levels shewed a depression of 8.634, [illegible] continued fall of country [illegible] in advance, on the 6th mile [illegible] a rise took place which restored the amount [illegible] to the original series on which the profile had existed previously to reaching the low land [illegible] Futtehpoor. The following table showing the amount of depression at each mile [illegible] exemplify the interruption in the uniformity of slope, caused by the 6 miles of hollow [illegible] alluded to. From the 360th to the 382 mile [illegible] at a point close to the Town of Futtehpoor the slope was 16.43 ft or 0.746 feet per mile. From the 390th or from the point where the hollow terminates the slope continues at about 12 inches per mile which in calculating the levels from the 360th to the 410th mile will be found to be the true average of the slope of the Country

360th Mile	.	526.59 ft	on the zero point of my [illegible] above [illegible]
382	.	[illegible] 3.05	
383	.	54[illegible].28	sudden fall of 4.28 [illegible]
384	.	551.63	
385	.	552.68	[illegible]
386	.	55[illegible].39	
[illegible]	.	558.76	
[illegible]	.	5[illegible].58	
[illegible]	.	55[illegible].74	level regained at [illegible] mile
[illegible]	.	[illegible].59	
[illegible]	.	5[illegible].97	
410	.	5[illegible].35	

At the 49th mile and in the approach of the course of the Canal to Binnaguri, the surface of the country which has been continuing on a steady slope of about 1 foot per mile, abruptly takes up a level 4 feet lower and proceeds ~~[illegible]~~ in advance on a slope similar to that it had [illegible] at the west of the [illegible]. This sudden variation will be best understood by a series of figures which represent the depression of the surface at each mile below the zero point of [illegible] levels.

From the 39th to the 49th mile the slope of the surface [illegible] is 9.03 feet or .902 per mile. Thus

39th mile	378.13
49th "	387.15
50th "	391.24
60th "	403.26

[illegible] the 49th [illegible] 60th [illegible] again [illegible] the 60th [illegible] the country [illegible] the slope [illegible] is [illegible] 12 [illegible] per mile [illegible] carried to the [illegible] change occurs at [illegible]

[illegible] relative position [illegible] lines of the [illegible]

[illegible] crossed [illegible] Lodhwan [illegible] course that the [illegible] maintains over all [illegible]

		Below the [illegible]		
		[illegible]	[illegible]	[illegible]
		Feet	Feet	Feet
	35° [illegible]	5·35	–	76·75
	40° "	3·66	7·57	77·65
[illegible]	45° "	2·14	3·[illegible]	79·68
[illegible]	50° "	4·01	1·66	63·75
	55° "	7·33	3·16	23·41
[illegible]	60° "	7·94	3·25	99·[illegible]
	65° "	12·63	4·45	94·36

The Section of the [illegible] at the 60th [illegible] as follows:

Diag. XLVII

[illegible] the [illegible] the [illegible] the [illegible] [illegible].

The average depth [illegible] is as follows:
[illegible] 35° to 40° [illegible] 6·75 feet
40° to 60° do 9·80 "
60° to 65° do 7·25 "
[illegible] 65° do 7·94 "

The [illegible] is [illegible] partially accompanied by the [illegible] [illegible] to [illegible] occasionally [illegible] with [illegible]; it appears [illegible] amount or [illegible] to which I [illegible] as characterising the [illegible] in the [illegible].

The depth of [illegible] measuring from the surface of the Earth to the surface of [illegible] is

On the left of the Canal line		On the Right of the Canal	
Maximum	31 feet	Maximum	105 feet
Minimum	21 "	Minimum	21 "

[illegible] of [illegible]

[illegible] the Bridge at [illegible], the following works [illegible] [illegible].

1st Bridge at [illegible] 3 arches of 26 feet each 18 feet roadway with Ghats [illegible] and [illegible] heads and a 1st class [illegible] attached.

2nd Bridge at [illegible] 3 arches of 26 feet each _ 18 feet roadway, with Ghats, [illegible] and [illegible] heads attached also a 1st class [illegible]

3rd [illegible] Bridge _ 3 arches of 26 feet each _ 18 feet roadway with Ghats [illegible] and [illegible] heads, and a 1st class [illegible] attached

4th Bridge at [illegible] 3 arches of 26 feet each _ 18 feet roadway with Ghats, [illegible] and [illegible] heads, and a 2nd class [illegible] attached

5th Bridge at [illegible] 3 arches of 26 feet each _ 18 feet roadway with [illegible] and [illegible] heads, Ghats and a 1st class [illegible] attached

6th Bridge at [illegible] 3 arches of 26 feet each _ 18 feet roadway with Ghats, [illegible] and [illegible] heads, and a 1st class [illegible] attached.

7th Bridge at [illegible] 3 arches of 26 feet each _ 18 feet roadway, with Ghats [illegible] and [illegible] heads and a 1st class [illegible] attached

8th Bridge at [illegible] _ 3 arches of 26 feet each _ 18 feet Roadway. with Ghats [illegible]

[illegible]

9th [illegible] at [illegible] 3 [illegible] 26 [illegible] 18 [illegible] with [illegible]

10th Bridge at [illegible] 2 [illegible] 33 [illegible] 25 [illegible] roadway with [illegible]

11 [illegible] at [illegible] 2 [illegible] 33 feet [illegible] 18 [illegible] roadway with [illegible]

12 [illegible] at [illegible] 33 [illegible] 16 [illegible] roadway with [illegible]

[illegible] 65th & 120th mile [illegible] 7 [illegible] 65th mile [illegible] parallel [illegible]

at that point [illegible]
and afterwards [illegible]
[illegible]
its [illegible]
proceeding [illegible]
[illegible]

Diag: XLVIII.

[illegible] from its heads [illegible]

[illegible] ~~and~~
~~[illegible]~~
~~[illegible]~~ [illegible] that [illegible]
[illegible]
[illegible] would be
[illegible] that [illegible], with the
[illegible]

[illegible]
[illegible] that river
[illegible] lying
within [illegible]
[illegible] the
[illegible]
[illegible] as far as
relates to the course and direction
of [illegible], and it is [illegible]
[illegible]
[illegible], and consequently
to be so [illegible] a place in
the tables; that its existence
[illegible] must be presumed.
[illegible] the [illegible]
[illegible] between
the 63rd and 71st [illegible]
[illegible]

[illegible] the [illegible]

[illegible] the [illegible] becomes [illegible] that [illegible] the [illegible]

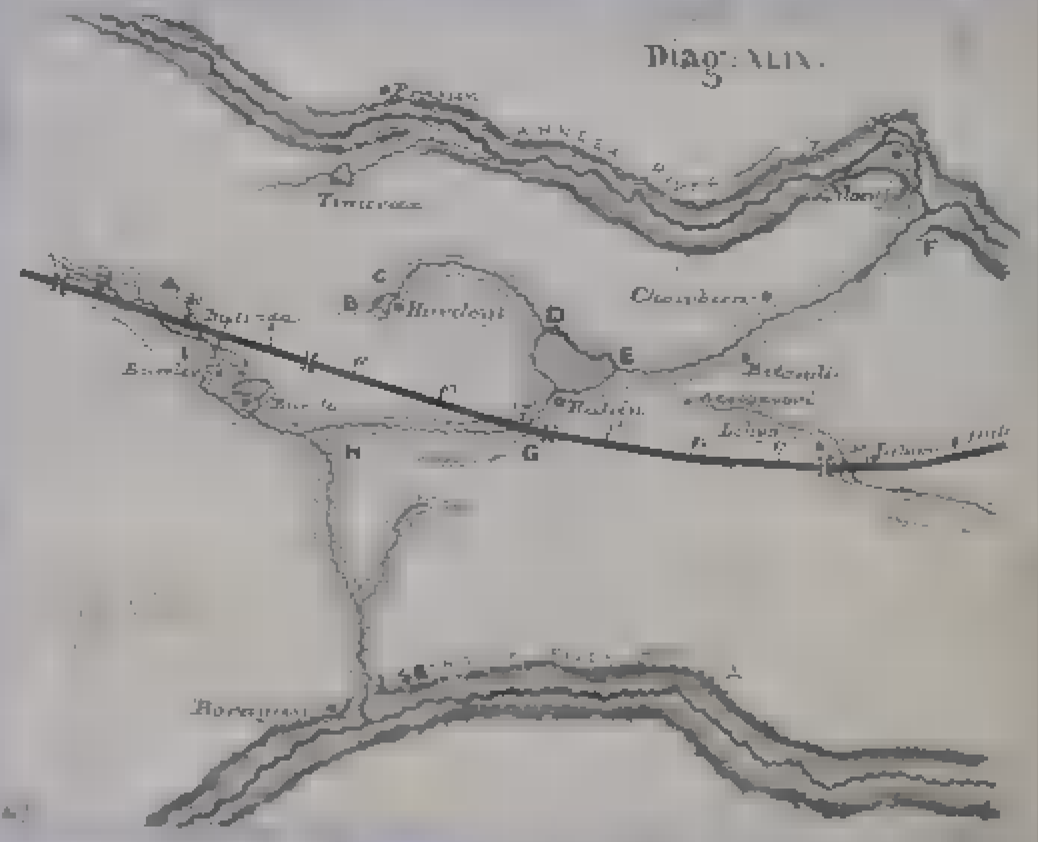
[illegible] ; it [illegible] a difficulty [illegible] of the 18th [illegible] passes over a high [illegible] the 21st [illegible] with a [illegible] of no importance [illegible] at the 3rd [illegible] ~~[illegible] importance~~ ; it is [illegible] heads [illegible] the [illegible] the [illegible]

[illegible] the 21st and 22nd [illegible] between the [illegible] and the [illegible] particular [illegible] ises, as [illegible] hollows connect the two rivers, although at [illegible] points the natural slope most unmistakeably lies across the line upon which

P. 345

[illegible] the [illegible]; the nature of the drainage will be [illegible] in a diagram. —

Diag: XLIX.



The road [illegible] drainage [illegible] at the point of [illegible] 24th [illegible] after have passed over about 2 miles [illegible] running parallel to the [illegible], at this point there [illegible] the [illegible] [illegible] [illegible] to the Burote [illegible]; at the [illegible] the water [illegible] during the night [illegible] the Burote [illegible] towards the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] communicate with the [illegible], the [illegible] the country [illegible] [illegible] [illegible] to the [illegible] of the [illegible], [illegible] the village of Boragiu [illegible]

150 feet, [illegible]
[illegible] the position [illegible]
[illegible] At the 9th
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
A [illegible] B, [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] with the
[illegible] to the
[illegible]
[illegible]
[illegible]
necessary [illegible]
to the [illegible]
[illegible] of the
[illegible]
[illegible] to [illegible]
[illegible] the
[illegible] boundaries.
[illegible] that
[illegible]
[illegible] 150 feet [illegible]
[illegible] should be [illegible]
on the [illegible] the
8th [illegible] by the dredge and
[illegible] to the [illegible]
[illegible], on the [illegible] is
the [illegible] AB CD. EF and
that [illegible] dimensions
should be excavated on the right
side.

[illegible] ~~[illegible]~~ Canal [illegible]
[illegible]
[illegible] I and G to the
[illegible] as follows
to the [illegible] H, [illegible]
[illegible],
[illegible] be kept well open to
admit [illegible] passage
[illegible] water.

[illegible]
[illegible] annual
[illegible]
[illegible] natural
[illegible] lands
[illegible] for the purposes
of irrigation [illegible]
[illegible] deficient
[illegible] part of [illegible]
[illegible] altogether the
[illegible] ~~[illegible]~~ operations will
~~of~~ these [illegible] will add
greatly to the value of the
[illegible]
[illegible] of fresh water
towards the [illegible]
side and towards the [illegible]
[illegible].

[illegible] of the [illegible]
[illegible] at [illegible] the canal and
on a course almost due south
[illegible]
[illegible] the village
[illegible]
[illegible]
by the [illegible] 1st [illegible] the
[illegible].

At the village [illegible]
[illegible]
[illegible] towards
the [illegible] at the point
of

[illegible] of the [illegible]
[illegible] necessity
[illegible] (~~[illegible]~~ *item*) [illegible]

[illegible] 116th [illegible] that
[illegible]
[illegible] passing
[illegible]

and the Canal [illegible] at this point [illegible] within a quarter [illegible] the [illegible] passes onwards

[illegible] 113th [illegible] 109th [illegible]

[illegible] 113th [illegible] ~~proceeds~~ [illegible] as a [illegible] straight line [illegible]

[illegible]

[illegible] Neysori ka Poorwa [illegible]

Diag: L

[illegible] A [illegible] A & B [illegible] No. 115 [illegible] ~~use to suffer~~ [illegible] is situated at the 103rd [illegible]

[illegible] with a [illegible] of
[illegible]
[illegible] for the [illegible]
[illegible] into [illegible]
[illegible] the
[illegible]
[illegible] may [illegible] into
[illegible]
[illegible]
it may [illegible]
[illegible] that [illegible]
[illegible] of
the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] of the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] of the [illegible]
[illegible] that the
[illegible]
to [illegible] feet [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible]

	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2000.

For further remarks on this [illegible] see Part 3. [illegible] under the head of [illegible]

[illegible]
the [illegible] the [illegible]
the [illegible] is equal to [illegible]
[illegible] of [illegible] feet [illegible]
[illegible]

[illegible]

(p. VIII.),

tandem [illegible]

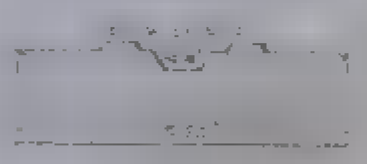
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Depth of the Canal: max.	min.	Height of the Canal: max.	min.
	[illegible]	–	–	–	–	–	[illegible]	[illegible]		–		+[illegible]	38	23	90	23
	[illegible]					–	[illegible]	[illegible]		–	–	3.56	38	25	90	25
[illegible]			+[illegible]	–			[illegible]	[illegible]		–		[illegible]	33	18	90	31
	[illegible]	–	–	+[illegible]		–	7.7	[illegible]	–	–	–	[illegible]	35	24	90	30
[illegible]				[illegible]		–	7.7				+[illegible]	[illegible]	40	29	90	35
[illegible]	96	+12.11	–	[illegible]	+[illegible]	–	[illegible]	–	–	–		14.15	40	28	90	33
	[illegible]	[illegible]	–	[illegible]			[illegible]	–	–	+26.35	–	16.93	40	23	90	30
	[illegible]	[illegible]	–	13.21		–	3.99	–	–	–		21.06	32	24	105	30
[illegible]	[illegible]	–		[illegible]			[illegible]	–	+27.[illegible]	[illegible]	–	[illegible]	27	22	77	16
[illegible]	[illegible]	–		–		+15.38	[illegible]	–	–	–	–	[illegible]	32	20	72	25
	[illegible]			–		–	13.73	–	–			[illegible]	37	–	80	[illegible]

[illegible]

[illegible] 120 [illegible]
[illegible]

Table LI.

[illegible]



[illegible]

[illegible]	6·05	6·30 [illegible]
[illegible]	4·90	6·44 [illegible]
30th [illegible]	5·36	5·83
[illegible]	7·36	5·33
70th	4·59	5·33
[illegible]	6·40	5·92
101st	7·38	5·78
102nd	6·41	6·68
110th	7·58	5·22
115th	4·71	6·58
120th	6·03	

[illegible]

A.A, 353, VI.

the [illegible]

[illegible]

at 105 [illegible]

[illegible] 18 [illegible]

[illegible]

1st [illegible] 33 [illegible]

2nd [illegible] 33 [illegible]

3rd [illegible] 33 [illegible] 1st [illegible]

4th [illegible] 2 [illegible] 33 [illegible]

5th [illegible] 35 [illegible]

6th [illegible] 2 [illegible] 33 [illegible]

7th Bridge at [illegible]
2 [illegible] 30 [illegible] 15 [illegible]
[illegible] with [illegible]
[illegible] 2nd [illegible]
[illegible]

8th Bridge at [illegible] 2
[illegible] 30 [illegible] 15 [illegible]
[illegible]
[illegible] 1st
[illegible]

9th Bridge at [illegible]
2 [illegible] 30 [illegible] 20 [illegible]
[illegible] with [illegible]
[illegible] 2nd class
[illegible]

10th Bridge at [illegible]
2 [illegible] 30 [illegible] 15 [illegible]
[illegible] with [illegible]
[illegible] 2nd [illegible]
[illegible]

11th Bridge at Goreyeea
2 [illegible] 30 [illegible] 15 [illegible]
[illegible] with [illegible]
[illegible] 2nd class
[illegible]

12th Bridge at [illegible]
2 Arches [illegible] each. 18
[illegible]
[illegible] 1st class
[illegible]

Bridge at Bahurpoora
2 Arches of 26 each. 18 [illegible]
roadway with [illegible]
[illegible] and a 2nd class
[illegible]

14th Bridge at [illegible]
2 [illegible] 26 [illegible] 18
[illegible] with [illegible]
[illegible]
[illegible]
[illegible] 3 [illegible]
2 [illegible]
[illegible]

15th Bridge at [illegible]
2 [illegible] 26 [illegible] 18 [illegible]

[illegible]

[illegible] with [illegible], [illegible]
[illegible] [illegible] [illegible]
[illegible]

16th [illegible] at [illegible]
[illegible] 20, [illegible] 15 pd
[illegible]
[illegible]
[illegible]

17th [illegible] at [illegible]
[illegible] 20 per [illegible] 15 pd
[illegible]
[illegible]
[illegible]

18 [illegible] at [illegible]
[illegible] 20 per cent 16 pd
[illegible] with fruits [illegible]
[illegible]
[illegible]

19th [illegible] at [illegible]
[illegible] 24 per [illegible] 18 pd
[illegible] with fruits, [illegible]
[illegible] 1st [illegible]
[illegible]

20th [illegible] at 13 [illegible] 2
[illegible] 26 per [illegible] 18 pd
[illegible] with fruits [illegible]
[illegible]
[illegible]

[illegible] (Continued)
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] degrees [illegible]
[illegible]
[illegible]
[illegible]

[illegible] [illegible] [illegible] [illegible] line [illegible]
[illegible] [illegible] to the 103rd mile [illegible]
[illegible] radius [illegible], at the
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible] to
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] of
the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] 103 [illegible] and to
[illegible] [illegible] [illegible] of [illegible] [illegible] of
Dawson; [illegible] this point another
[illegible] [illegible] radius [illegible]
[illegible] [illegible] point (at the 105th mile)
[illegible] [illegible] [illegible] [illegible] run
[illegible] the South [illegible] the
[illegible] [illegible] [illegible] the [illegible].

It will be understood, then, that the [illegible] of the
[illegible] [illegible] point [illegible]
is [illegible] [illegible], after running
parallel [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible], and has
[illegible] [illegible] the said [illegible],
[illegible] at the 104th mile [illegible]
about a sweep to the South
passing [illegible] the [illegible] of
[illegible] [illegible] and Dawson having
[illegible] [illegible] [illegible] [illegible], and
[illegible] the [illegible], [illegible]
[illegible] [illegible] [illegible], and [illegible]
[illegible] [illegible] [illegible] [illegible]. ~~to [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] parallels.~~

The [illegible] [illegible]
[illegible] [illegible] the [illegible] point
[illegible] the [illegible] [illegible] [illegible]
[illegible] at the 116th mile [illegible] [illegible]

[illegible]

taken at [illegible] equal to
[illegible] to [illegible]; at [illegible]
[illegible], [illegible] between the
[illegible] [illegible] [illegible]
[illegible] the [illegible] [illegible]
takes place, the [illegible] is the
[illegible] [illegible], [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] to the [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible], [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] ~~[illegible]~~
~~[illegible]~~ [illegible] [illegible] [illegible]
[illegible] [illegible] separation
[illegible] distance of about [illegible])
[illegible] [illegible] [illegible]
by the [illegible] [illegible], and by the
[illegible] and [illegible] [illegible]
[illegible] [illegible] with the [illegible]
[illegible] [illegible] at the immediate
[illegible], [illegible] [illegible] course,
[illegible] [illegible] will [illegible]
in greater detail [illegible], [illegible]
[illegible] [illegible] [illegible] [illegible]
arrangements [illegible] connected with
the [illegible] of [illegible] age.
To this [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
with the [illegible] [illegible] Keyserik Baruwa
and [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] described.
[illegible] the [illegible] [illegible]
[illegible] the [illegible] [illegible] [illegible]
the [illegible] [illegible], [illegible] [illegible]
and cultivated country, with
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible]

[illegible] a [illegible] of [illegible] this [illegible] the [illegible] only 3 [illegible] at the 14th, 15th and 17th miles [illegible], and the [illegible] and [illegible] this [illegible] with regard to the [illegible] that [illegible] [illegible] on the [illegible] of the [illegible] not [illegible] information in the [illegible] of the [illegible] as [illegible] to

It will be observed that the hollows which are cut off by the canal at the 12th and 13th miles are portions of drainage [illegible] connected with two distinct tributaries of the [illegible], to these [illegible], especially [illegible] [illegible] [illegible] at the [illegible]. [illegible] [illegible] in the [illegible] and [illegible] tributaries which have been separated from their parent drainage and be con-

-nected

each the [illegible]
[illegible] with [illegible] alternant
[illegible] as [illegible] marked at
AB and CD: [illegible]
A to B is [illegible]
and that from C to D [illegible]
[illegible] [illegible], [illegible] [illegible],
[illegible] [illegible] [illegible] [illegible]
10 [illegible] [illegible] [illegible] [illegible]
~~[illegible]~~ read [illegible] [illegible]
drainage [illegible] [illegible]
[illegible] [illegible], [illegible], ~~[illegible]~~
~~[illegible] [illegible] [illegible]~~ [illegible]
[illegible] drainage [illegible]
[illegible] [illegible] [illegible]
than ~~the [illegible]~~ we in reality [illegible]
[illegible] [illegible] [illegible]
the [illegible] of drainage [illegible]
in a [illegible] although [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] the [illegible] of the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible]
[illegible] with water, [illegible]
[illegible] [illegible] [illegible] ~~[illegible]~~
[illegible] only [illegible] [illegible] [illegible],
[illegible] of the bottoms, [illegible]
[illegible] the [illegible] [illegible] the
[illegible] [illegible] [illegible]
as [illegible] thus [illegible] and
[illegible] [illegible] depressions of such
[illegible] [illegible] [illegible] amount
that [illegible] [illegible] [illegible]
[illegible] will be [illegible]
At the [illegible] [illegible], a [illegible]
of the [illegible] [illegible] of the
[illegible] [illegible] [illegible] the [illegible]
[illegible] of the [illegible]
[illegible] [illegible] [illegible] and
[illegible] [illegible] [illegible] of the [illegible];
the [illegible] [illegible], [illegible] con-
-nect it with the drainage
of

[illegible] will [illegible]
[illegible]
[illegible] the
[illegible]
[illegible] the
[illegible]
[illegible] the [illegible] into action
with the [illegible] which
[illegible] with the [illegible] will
[illegible] equally, as
this [illegible] Canal [illegible]
passes over the summit level of
the Country and intermediately
between Rivers, the heads of which
are considerably depressed, it is
evident that a portion [illegible]
out [illegible] on the [illegible] may be
turned into the drainage passing
down [illegible] the Jumna, and that there
ought to be no inconvenience
to the drainage of the country
from the introduction of a
Canal or road which has been
conducted on the principles
above [illegible].

At the [illegible] [illegible]
[illegible] at a point between the
[illegible] and [illegible] miles, the line
[illegible] two miles parallel
[illegible]
tion [illegible] with the course of
a tributary of the Ganges
which [illegible] the [illegible]
[illegible] this is the first [illegible]

[illegible]

Fig: LIII

[illegible] with the Seyngoor. At a point opposite the village of [illegible], at

[illegible] in [illegible] drainage [illegible] and [illegible] [illegible] the [illegible] ABB will be [illegible] with the [illegible] the [illegible] [illegible] two [illegible] [illegible] will be [illegible] with see [illegible] may [illegible] [illegible] make [illegible] AB [illegible] the lower [illegible] A and if necessary to extend the [illegible] as far down as the junction of the valley with the [illegible]. I would make this cut 15 feet in breadth, and [illegible] as [illegible] slope as the [illegible] levels will admit of, by which means the whole of the drainage from the head [illegible] [illegible] as far down [illegible] as the [illegible] will be disposed of.

At the point where the [illegible] crosses the [illegible] [illegible] to establish [illegible] total 3 [illegible] [illegible] of [illegible] water [illegible] drained [illegible] [illegible] [illegible] cut [illegible] will [illegible] [illegible] the line marked CD in the diagram. This cut will be made 30 feet in breadth [illegible]

[illegible] [illegible] [illegible] would be
raised [illegible] [illegible] [illegible]
the [illegible] [illegible]
will [illegible] it, has become [illegible]
and [illegible] [illegible]
[illegible] [illegible] that [illegible]
Sitthamma Nulla at C at
least 25 feet, and as the distance
between C and D is [illegible], the
[illegible] will [illegible] [illegible]
[illegible] for the purposes of
[illegible]. [illegible] [illegible]
[illegible] [illegible] Nulla
[illegible] that [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible],
[illegible] [illegible] towards the [illegible]
and that this [illegible] [illegible]
satisfactorily [illegible] a [illegible]
cut EF [illegible] prolonga-
tion of the line of [illegible] will
still further [illegible] of the [illegible]
during floods, and at any rate
will [illegible] the water from
[illegible] the Canal
[illegible] at C, and in
a great degree [illegible] the
[illegible] and abrupt turn
that the Sitthamma drainage
would otherwise have [illegible]
[illegible] of [illegible] the [illegible]
Nulla. [For further remarks on this [illegible] see Part 3. Chap. 2. Sect III and [illegible] III. 11, 3,
The plan upon which
I have [illegible] this [illegible]
[illegible] [illegible] in principle
to that which has been [illegible]
described [illegible] the [illegible]
[illegible] at the village of
[illegible], at which point
the [illegible] of the [illegible] are

terminat[illegible]

[illegible]
[illegible] connected with
[illegible]
[illegible] drainage
[illegible]
[illegible] towards [illegible].
[illegible] 14th [illegible] the
[illegible] to the south
[illegible] the villages of
Doora and Susan, which
[illegible] grounds [illegible] the village
of [illegible] the
14th [illegible]
[illegible]
[illegible]
[illegible]
connected with the [illegible]
[illegible] the ostensible
roads.

13th at the 143rd mile
is the village of Doora, and at
the 145th mile [illegible] village of
Susan. [illegible]
[illegible] with the walls of [illegible]
[illegible]
the numerous villages [illegible]
[illegible] take their [illegible] in
neither case is the portion but
of a different [illegible]
[illegible] its [illegible]
[illegible]
[illegible]
[illegible]
villages [illegible] [illegible]
[illegible]
[illegible]
[illegible] all
[illegible]
[illegible] possible

[illegible]

[illegible]

Diag: LIV

[illegible]

[illegible] and kept all [illegible] [illegible], [illegible] [illegible] [illegible]
that the [illegible] [illegible]
[illegible] [illegible], [illegible] the
[illegible] [illegible] that it possessed
[illegible] that [illegible] the [illegible] of the
[illegible] [illegible] [illegible] cultiva-
[illegible] [illegible] [illegible] under the
[illegible] [illegible] [illegible] [illegible] [illegible],
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] was the
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible], [illegible]
[illegible] [illegible] [illegible] was ~~[illegible]~~ [illegible]
[illegible] [illegible] [illegible] [illegible], without
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] that [illegible] [illegible]
[illegible] without [illegible] means
of ~~[illegible]~~ giving facility to [illegible] [illegible] is [illegible]
deep [illegible] ~~[illegible]~~. [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
just [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible],
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible], as
well as [illegible] [illegible], [illegible] [illegible]
the [illegible] [illegible] of [illegible] [illegible]-
-gation.—

With regard to [illegible]
[illegible] it was [illegible] desirable that
[illegible] [illegible] [illegible] should be
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible]. [illegible] although

a [illegible]
the cause that [illegible]
[illegible] them [illegible]
between [illegible]
and the [illegible]
[illegible]
[illegible]
[illegible]

Plates [illegible] VIII, [illegible]
[illegible] illustrate the [illegible]
intimate [illegible] complication,
[illegible]
[illegible]
the present [illegible]
[illegible]
[illegible]
[illegible] LIV [illegible]
[illegible] subsequent [illegible]
[illegible]
[illegible]
[illegible]
[illegible].

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
character of the [illegible],
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the words [illegible]
[illegible]
[illegible]
[illegible]

[illegible] deposition [illegible]
[illegible]
[illegible]
the [illegible]
[illegible] plate
VIII [illegible]
[illegible]
[illegible]

The [illegible] which
[illegible] part of its course
[illegible]
[illegible] although
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] about [illegible] miles above
the [illegible]
[illegible] plas* [illegible]
[illegible]
[illegible]
and about [illegible] distant
from it. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible]
[illegible]
[illegible]

nnao

* [illegible]
[illegible]
[illegible]

[illegible]

[illegible] about 11 feet.

[illegible]

[illegible] might [illegible]

[illegible]

[illegible] portion [illegible] by [illegible] half [illegible]

[illegible] the [illegible] of [illegible] to the [illegible] [illegible] the [illegible] takes [illegible] the crossing [illegible] [illegible] [illegible] through [illegible] [illegible] [illegible] of the [illegible] the [illegible] the crossing, follows [illegible] [illegible] the place [illegible] the [illegible] between the [illegible] [illegible] to prevent this [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] difficulty. —

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] the [illegible] of the public
[illegible]
[illegible] with [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible] in the vicinity
and observations taken [illegible],
it [illegible] that [illegible]
[illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible] out [illegible]
[illegible]
[illegible]
[illegible]
Lieut. [illegible]
[illegible] is the [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] into the [illegible]
[illegible]
[illegible]
[illegible] pro-
[illegible]
[illegible] al-
[illegible] without [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] that the
[illegible]
[illegible]
[illegible] the [illegible]
[illegible] possible.
[illegible] aside, the [illegible]

[illegible] taking the
[illegible]
[illegible] the [illegible] of [illegible]
[illegible]

In concluding my descrip-
tion of the line laid down
[illegible], I will [illegible]
a [illegible] of the [illegible]
[illegible] the most [illegible]
of [illegible] patches of
[illegible] land near the
[illegible]. The [illegible] are in
[illegible] parts very deep, and the
supply of [illegible] limited, [illegible]
[illegible] of [illegible], so
that the necessity for [illegible]
[illegible] is at first apparent.
This line has no very great
difficulties to contend with,
except [illegible] with
the [illegible] they are
[illegible]
[illegible] that
should [illegible] be [illegible]
[illegible] the [illegible]
the protection [illegible]

If the [illegible] were
[illegible] side
of the [illegible] it would be
[illegible] by about [illegible] miles,
and [illegible]
[illegible]
[illegible] and the [illegible]
[illegible] would be at
[illegible] difficulty
as the [illegible] is
[illegible] Denmark
[illegible]
[illegible]
[illegible]
[illegible]

[illegible] a [illegible] supply [illegible] water [illegible] [illegible] [illegible] [illegible] [illegible]

1st. [illegible] occupy [illegible] the [illegible] which [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

2nd. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Stocia, [illegible] [illegible] [illegible] [illegible] that [illegible] would [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] would [illegible] [illegible] [illegible] the [illegible] [illegible] would [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

... one [illegible] ...

... be [illegible] over the [illegible] ... Aqueduct. [illegible] ...

... [illegible] ...

1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	363 [illegible]
7	[illegible]	[illegible]
8	Gibsee	508.19
9	[illegible]	509.[illegible]

[illegible] Towns & principal [illegible] ... on the land [illegible] ...

[illegible]

Sig 2.B. P.369;1.1.

the following levels.

Khatimpoor 21?.33
[illegible] 570.80
New Sumbalpur 5??.13

The distance from the [illegible] head to New Suhanaini is along the line marked by [illegible] about 61 miles the fall of country in this distance is equal to 36.79 feet or about 0.??? feet per mile.

From Khatimpoor to Gynaur the distance is [illegible] miles, and the fall of country is equal to 16.62 or 1.6 feet per mile. From Gynaur to Khatimpoor the distance is nearly 11 miles the fall of country is equal to 7.53 or 0.68 feet per mile, the level point at Khatimpoor however is taken on the North [illegible]. [illegible] in the direct line [illegible] has been [illegible] the fall. The town of Khatimpoor itself is [illegible] at 508.42 but the country [illegible] may [illegible] all sides. [illegible] the table above given it will be seen that the points at [illegible] and ~~Khatimpoor~~ Gynaure are nearly upon one level.

The change in the direction of the Canal therefore [illegible] to the [illegible] construction [illegible] has [illegible] deprived the Khatimpoor [illegible] of the benefit of Canal irrigation.

[illegible] [illegible] this [illegible]
the [illegible] [illegible] of the [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] with the
detail of those on the map
[illegible] of the same [illegible]
at the 159th Mile [illegible] the [illegible]
of [illegible]. The [illegible] [illegible]
[illegible] [illegible] by the intersection
of the Canal [illegible] [illegible]
below [illegible] [illegible], [illegible]
off [illegible] the [illegible] [illegible]
[illegible] [illegible] naturally [illegible]
[illegible] [illegible] [illegible] into the [illegible]
[illegible] by a [illegible] marked on
the [illegible] [illegible] AB, which [illegible]
[illegible] [illegible] with a [illegible] of
low land ~~[illegible]~~ [illegible] [illegible]ing
under the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
to the [illegible] [illegible] bordering
the [illegible] [illegible].

Below the 159th mile the
Canal [illegible] a course to
the South East [illegible] (between
the 161st and 162nd mile) the line
of [illegible] [illegible] [illegible]
half a [illegible] [illegible] the right of
the [illegible] the high road [illegible]
[illegible] [illegible] [illegible]
the Canal. In the 163rd mile the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] to the right
and immediately opposite
the 165th mile; at the 166th
mile [illegible] 400 yards ~~[illegible]~~
~~[illegible]~~ [illegible] the village
of [illegible] [illegible] [illegible]

[illegible]

[illegible] the [illegible]
[illegible]
[illegible] village
[illegible] designate the [illegible]
[illegible] of the [illegible]
[illegible] course of about 2½
[illegible] the [illegible] near
the village [illegible], and
the [illegible] road [illegible] along the
[illegible]
[illegible].
[illegible] this valley
[illegible] the village
of [illegible] see [illegible]
[illegible]
distance is about [illegible]
[illegible] the
[illegible]
[illegible] natural
consequence, [illegible] will
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible] see [illegible] the [illegible]
[illegible] the
[illegible] the village
of [illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible] 360 [illegible]
[illegible] the village
of [illegible] doubt
[illegible] the
[illegible] the
[illegible] see [illegible]
[illegible] situation [illegible]
[illegible] would lead to
the [illegible]
adapted to the purposes of [illegible]

[illegible] 115° [illegible] 115°
[illegible] a [illegible] [illegible]
[illegible] [illegible] [illegible] a
[illegible] degree [illegible]
[illegible] [illegible]
[illegible] pass [illegible]
-ing [illegible]
[illegible]
[illegible]
at ~~[illegible]~~
to the [illegible] passes
[illegible] moderation [illegible]
[illegible]
[illegible]
[illegible]
-age [illegible] 15
[illegible] at [illegible]
[illegible]
[illegible]
[illegible]
and [illegible]
and [illegible]
the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] affairs
[illegible]
[illegible] -age
[illegible] opposite direction
[illegible]
[illegible]
[illegible]
appears to [illegible] at this point
and [illegible]
[illegible]
[illegible]
172 [illegible]
[illegible]
[illegible]
at

in this point [illegible] it reaches [illegible] of the high [illegible] that [illegible] the [illegible], [illegible] would be [illegible] by [illegible] blocks - [illegible] River at the [illegible]

[illegible] between the [illegible] and the [illegible] [illegible] the [illegible] passed [illegible] the 145th [illegible] at [illegible] we on [illegible] the [illegible] of the [illegible] equidistant [illegible] the two [illegible].

[illegible] of the [illegible] the 121st [illegible] of the high [illegible] is equal to [illegible] feet [illegible] is equal to [illegible] feet

The relative position of the [illegible] of the Rivers as de- [illegible] from [illegible]'s [illegible] are [illegible] in the following table; the plus and minus quantities [illegible] elevation or depression [illegible] the [illegible] the [illegible]

[illegible]														
125°	-16·[illegible]	+25·03	—	—	—	—	—				+20·56	[illegible]	80·41	[illegible]
130°	-11·0[illegible]	—	—	—	—	—	—	—			26·06		79·16	[illegible]
135°	-17·77	—	—	—	—	—	—	—	—	—	[illegible]	—	102·16	[illegible]
140°	+33·[illegible]	—	+3[illegible]	—	—	—	—	—	—	—	[illegible]		79·45	36·73
145°	+30·[illegible]	—	—	+30·7[illegible]	+45·62	—	—	—	—	—	[illegible]	—	91·[illegible]3	[illegible]
150°	+37·[illegible]	—	—	+32·7[illegible]	—	+15·80	+2[illegible]	—	—	—	45·[illegible]2	+47·67	64·45	[illegible]
155°	—	—	—	+1[illegible]	—	—	+31·27	+28·[illegible]9	—	—	23·[illegible]	—	87·[illegible]	30·[illegible]
160°	—	—	—	+13·16	—	—	—	—	—	—	31·05	—	[illegible]1·[illegible]3	[illegible]
165°	—	—	—	—	—	—	—	—	+40·0[illegible]	—	39·46	—	[illegible]1·08	[illegible]
170°	—		—	+11·39	—	—	—	—		—	45·74		27·41	[illegible]
175°				+[illegible]	—					+30·07	30·61		86·91	[illegible]
180°	—			+[illegible]	—						1·08		77·68	[illegible]
[illegible]												-60·10	7[illegible]·[illegible]4	[illegible]

[illegible]

Diag. LV.

[illegible]

125° … 130° … 135° } 6[illegible]

140° … 145° … 150° } 7[illegible]

155° … 160° … 165° } 6·08

170° 8·45

175° 12·0[illegible]

[illegible] Allawa [illegible] [illegible] [illegible] also [illegible] away as [illegible] the [illegible] [illegible] and [illegible] the [illegible]

[illegible] feet, and [illegible] feet. The [illegible] taken from the [illegible]

[illegible] the [illegible] situated [illegible] 11 [illegible] and 119 miles [illegible]

[illegible]
18 feet [illegible] with [illegible] and [illegible]

[illegible] at [illegible]
35 [illegible]
18 feet [illegible] with [illegible] and [illegible]

3 [illegible]
35 feet [illegible]
18 feet [illegible] with [illegible]
[illegible]

[illegible] 1st [illegible]

4th Bridge at [illegible]
33 feet waterway in 1 arch
18 feet roadway with [illegible]
[illegible]
a 2nd [illegible]

5th Bridge at [illegible]
33 feet waterway in 1 arch
18 feet roadway with [illegible]
[illegible]
a 2nd [illegible] [illegible] with an Escape

6th Bridge at [illegible]
33 feet waterway in 1 arch
18 feet roadway with [illegible]
[illegible]
a 2nd [illegible]

7th Bridge at [illegible]
33 feet waterway in 1 arch
[illegible] feet roadway with [illegible]
[illegible]
a 2nd [illegible]

8th Bridge at [illegible]
30 feet waterway in 1 arch
18 feet roadway with [illegible]
[illegible]
[illegible]

9th Bridge at Nurhea
30 feet waterway in 1 arch
18 feet roadway with [illegible]
[illegible]
~~[illegible]~~
~~[illegible]~~ 2nd [illegible]
[illegible]

10th Bridge at Ukburpoor
30 feet waterway in 1 arch
25 feet roadway with
[illegible]
and a 2nd [illegible] attached

11th ~~Bridge~~ Tally and works at Rubbipoor
~~30 feet waterway in 1 arch~~
~~20 feet roadway with [illegible]~~ Parapets

Similar to those on the Main, and has only 1 chamber of 30 feet waterway. Roadway of Bridge 25 feet broad, with [illegible] [illegible] in the [illegible] in the [illegible] position

~~[illegible]~~
~~a 1 [illegible] attached~~
12th Bridge at Koorau
36 feet [illegible] in Bed
16 feet roadway with [illegible]
[illegible]
a [illegible] attached
13th Bridge at Saffiabad
26 feet water way in Bed
13 feet roadway with [illegible]
[illegible]
and a 2 [illegible]
14th Bridge at [illegible]
26 feet [illegible]
16 feet roadway with [illegible]
[illegible] heads and
2 [illegible] attached
15th Bridge at [illegible]
34 feet [illegible]
13 feet roadway with [illegible]
[illegible] wall, and
a 1 [illegible] attached
16th Bridge at 12 [illegible]
20 feet water way in Bed
20 feet roadway with [illegible]
[illegible]
2 [illegible] attached
17th Bridge at
feet water way
feet roadway with [illegible]
[illegible] heads and
[illegible] attached
18th Bridge at
feet water way
feet Roadway with [illegible]
[illegible] heads and
2 [illegible] attached
19th Bridge at
feet water way
feet Roadway with [illegible]
[illegible] heads and
2 [illegible] attached

~~[illegible]~~

17° [illegible] [illegible] [illegible] that of the [illegible].

18° [illegible]

19° [illegible] Plate XLVI [illegible].

At this point [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] throughout the [illegible] [illegible] [illegible] [illegible] [illegible] Diagram XVII, figure II, bearing [illegible] actual measurements, ac-

-cepting

[illegible]

~~[illegible] 56 [illegible]~~

[illegible]

[illegible]

the [illegible] line of [illegible] under which were the [illegible] & level [illegible] after them in place at the point C ([illegible] LVIII) near the [illegible] [illegible] use of

[illegible]	V	[illegible]	
R	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] the deep [illegible]
[illegible] although
[illegible] deep [illegible]
[illegible]
~~[illegible]~~

the depth [illegible] 12 inches [illegible]
[illegible] the 23rd [illegible]
[illegible] depth [illegible] 15
[illegible]
[illegible] the
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

~~[illegible]~~

~~[illegible] 2d [illegible]~~

~~[illegible] 15 [illegible]~~

~~[illegible]~~

~~[illegible] of [illegible] between~~
~~the [illegible] [illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible] Department [illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~

The difficulties [illegible] the
[illegible] [illegible] of
of books in the [illegible]
[illegible] [illegible] [illegible]
Standard [illegible], the [illegible] 1863 [illegible]
[illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
was [illegible] [illegible] [illegible] [illegible]
[illegible] nearly the same,
[illegible] the [illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
[illegible] in the [illegible]
[illegible] [illegible] a double demand
upon [illegible] [illegible]
[illegible] [illegible]
[illegible], however,
[illegible] [illegible]
[illegible] [illegible]

with

without difficulty, than it was [illegible] and [illegible] and we have [illegible] to the great economy [illegible] and [illegible] altogether [illegible] as was possible [illegible]. [illegible] [illegible] attained [illegible]. [illegible] material [illegible] [illegible] but [illegible] quality [illegible] great [illegible] [illegible] obtained from the Basalt [illegible] in the [illegible] district, [illegible] [illegible]

Mosaic [illegible] [illegible] and [illegible] Car[illegible] is so compact as to be wanting in one of the most marked characteristics of [illegible], viz. its [illegible], many of the rocks which have been used in the [illegible] and which were [illegible] from the [illegible] of the [illegible] in the [illegible] and [illegible] [illegible] is compact, as that of the [illegible] Bath Court. The material is [illegible] excellent, but as I have [illegible], great discrimination is required in its use it is essential that the outer surfaces which are [illegible]

of

[illegible] and [illegible] together with [illegible] the [illegible] fully [illegible] leaving the roads [illegible] the [illegible] of the natural [illegible] to [illegible] that the [illegible] to [illegible] they [illegible] their [illegible].

[illegible] of the [illegible] is [illegible] similar to that of the [illegible], the [illegible] adapted to the [illegible] of the [illegible] in [illegible] of the [illegible] paths, [illegible] of the [illegible] arrangement of [illegible] Roads, [illegible] in every way with ~~that~~ those [illegible].

[illegible] applies equally to the [illegible] which are [illegible] to the [illegible], and [illegible] the [illegible] with the [illegible] and [illegible] in [illegible] The [illegible] in all cases has been to avoid as much as possible the separation of the [illegible] and especially that of the heads for Irrigation, [illegible] or Escape.

Escape from the immediate control and supervision of the [illegible]. It will be evident that throughout the course of this project, the Regulator Heads and Bridges being designed as a component part of [illegible], become accessible from both sides of the Canal; the Escape Heads being placed in connection with the Revetments attached to the Regulator Heads, to render secure the advantages, and the Establishment of a Chowkee post, by the construction of a building sufficient for the accommodation of the necessary guard, in the immediate vicinity of [illegible] a [illegible], or the [illegible] places the whole machinery viz. of Regulation, Heads and Escapes under the immediate supervision and easy control of the Canal Establishment.

The Heads of Irrigation are situated at nearly every Bridge, with modifications depending on local circumstances their dimensions being the same as those on the Main trunk line from the Head at Hurdwar to the 31st mile, or to the Bridge at [illegible]; the width of water-way is 10 feet, with its sill raised 24 inches above the Canal bed. From the [illegible] to the 91st mile, or to the Budaungee Bridge, ~~the water-way is diminished to 8 feet, with its sill raised to a height of 18 inches above the Canal bed.~~ [illegible]way is raised only 16 inches above the Canal bed, whilst the width of waterway ~~[illegible]~~ is reduced to 6 feet. From the 91st to the 181st mile the waterway is returned to the width of 4 feet with its sill raised 6 inches above the bed of the

Canal

Canal. From the 151st mile to the Terminus, the Beds are diminished to 6 feet width, but their sills are laid on the [illegible] and [illegible] of the old river Channel.

The Outlets or Escapes have been placed as nearly as possible about 12 miles apart, and at similar distances to those on the Cawnpore Branch; these sites are at Mirzapur, Jouthoori and Sikandra; the Escape which is connected with the Terminal works being considered as a portion of the works attached to the Lockage, and not coming under the classification of a separate building.

The views which I have entertained with regard to the postponement of the works on the Futtehgurh, Bolundshuhur and Koel Branches, and to which I have drawn attention in a former chapter, have inclined me to place the Terminal works on the Cawnpore line in abeyance, at least to postpone their execution until the supply of water at the extremities of these long lines is more accurately [illegible] and determined; this postponement may in fact resolve itself simply into a prosecution of the works when the progress of operations arrive at that particular point, or to a delay of 2 or 3 years; but with the principle of the use of the

Terminal

Terminal works on the Cawnpore line which are now under completion, we shall be able to form an opinion as to the immediate necessity of forming a connecting link for navigation purposes with the Jumna, by seeing how far the canal supply which, at the first, perhaps will be comparatively large, will act in maintaining a head water on the Cawnpore [illegible] points; the delay at any rate in completing the terminal works on the Canals will not be very great, in enabling us to act on most valuable experience gained, without in any way interrupting the main object of supplying Irrigation to the Country. The delay moreover, will give us the means of collecting material in sufficient quantities, to provide for an uninterrupted completion of the works, instead of carrying them on by the hand to mouth process that has characterized the progress of the Cawnpore Terminal works, which we have an object in finishing off at once.

I have proposed therefore, that for the present the works on the Etawah line should terminate at the Bridge and Escape at Etawah, or at the 141½ mile of its course. The works at Etawah are of considerable extent and importance. They

will

will form a 1st Class Depôt, and the residence there of the Head Quarters of the Division will enable the Executive Engineer to collect materials, and to make arrangements for with... [illegible] completing the works which are situated thereat; [illegible] Rajbaha heads with their waterways of eight feet in width and with their sills on a level with the canal bed, will be attached to the bridge at this point; that one on the left will pass off the water for the temporary supply of the country between the Hindon and the [illegible], whilst that on the right will afford the means of Irrigation to the country lying on the west of the Hindon at Lohunpoor. I use the expression 'temporary' because on the completion of the Canal Channel below the Sitthouna bridge, the Rajbaha heads which are situated below that and Lohunpoor will send their water to the line of Rajbaha which passes on to [illegible] Shahpoor and Kora Sultanabad.

On the subject of [illegible] I may observe [illegible]

[illegible]

Boundary [illegible]

[illegible] such
may be considered sufficient, the
capacity of the [illegible] of
the [illegible] Canal [illegible]
[illegible] [illegible]
[illegible] [illegible] and a [illegible]
[illegible] [illegible] considerably
[illegible] [illegible] [illegible]
of the [illegible] [illegible] [illegible]
[illegible] being [illegible]
[illegible] Hatrass [illegible]

~~[illegible]~~

~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
~~[illegible]~~

[illegible] [illegible] [illegible]
[illegible] with the [illegible] towns,
[illegible], the [illegible], the
[illegible], [illegible] [illegible]
[illegible] and [illegible] [illegible]
the [illegible] of transpor-
[illegible] [illegible] [illegible] to the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible], and
[illegible] [illegible] [illegible]
is a [illegible] [illegible], a fixed point
of level the [illegible] [illegible]
[illegible] upon the [illegible]
Roadway [illegible] on the
[illegible] [illegible] [illegible] Canal [illegible]
that on the [illegible] [illegible]
[illegible] [illegible] and [illegible]
[illegible] in breadth and depth but
would be exactly the same

The accommodation [illegible] the
[illegible]

establishment and for main-
tenance of a [illegible] of this part
is [illegible] that can
be [illegible]; [illegible] has
been taken to [illegible] the changes
[illegible] the Country [illegible] sub-
jected to [illegible] arising
from the [illegible]
to [illegible], throw
the [illegible] about the
Country, and to [illegible]
as much as possible the
inconvenience and evil [illegible]
dampness. [illegible]
[illegible] buildings which
are situated about 12 miles
apart, [illegible] found-
ation is to be attached on
the same [illegible] as [illegible] com-
pleted [illegible].

I have at the early part
of this Chapter explained
that the [illegible] of the County
which [illegible] the influ-
ence of the [illegible]
was subjected to a serious ex-
amination [illegible] but [illegible]
[illegible]
-dinal [illegible] Goldsworthy
the [illegible] attached to [illegible] works.
After [illegible] Goldsworthy's
[illegible] most satis-
factory [illegible]
had been done, Lieut. [illegible]
of the Bengal Engineers assisted
by Lieut. Johnstone of the same
Corps, commenced the works
in the cold season of 1850/51.
Since that period they have been
in active progress, Lt. Johnstone
having been succeeded in 1852
by

of Public Buildings & the En-
gineers; ~~and~~ [illegible] also
[illegible] 16th [illegible] and [illegible]
[illegible] of the [illegible], additional
assistants, [illegible]
[illegible] since the months
of [illegible] 1852 and [illegible]
1853 respectively. The State
of the Works in the beginning
of 1854 was very far advanced.
60 Miles had been completed
including both Earth and Mason-
ry work; 50 miles were in
active progress, and I have
no doubt that if my friend
[illegible] are con-
tinued (although I expect they will
be) until the whole is com-
pleted, the admirable system
[illegible] has enabled
him to make such ~~rapid~~ good
progress & [illegible] will secure
its [illegible] accomplishment, in
accordance with [illegible] of the
[illegible] in a period of
[illegible] years.

CHAPTER III.

[illegible] and [illegible]

In the preceding chapter I have endeavoured to describe in its fullest detail that portion of the [illegible] works [illegible] the [illegible] [illegible] [illegible] it [illegible] [illegible], the detail had [illegible] although [illegible] than the circumstances of the case [illegible]; it has been found [illegible] completed, and the [illegible] [illegible] state of progress, and the [illegible] [illegible] that particular part [illegible] the works [illegible] have so [illegible], that the detail has [illegible] [illegible] [illegible] delineation of the [illegible] of the country [illegible] state [illegible] the works actually completed, or in progress of completion. [illegible] specially to the [illegible] of the Canal from the [illegible] to the [illegible] Regulators, and [illegible] to the

[illegible] [illegible] and [illegible] Curves, [illegible]
[illegible] river [illegible] [illegible] into
[illegible] the [illegible] [illegible] [illegible]
[illegible].
[illegible] advantages were natu-
[illegible] the [illegible] to the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] to
describe, [illegible] the same
[illegible] investigation,
[illegible] A [illegible] [illegible] shewn

Fig 2 C. P. 385

[Fig 2] [illegible]. The preliminary
[illegible] although sufficient in
[illegible] [illegible] establishing points
[illegible] [illegible] [illegible]
[illegible] [illegible] the alien-
[illegible] measured, cannot
[illegible] [illegible] with accu-
racy [illegible] [illegible] upon which
[illegible] [illegible] the intricacies
of detail [illegible] the influence the
practical [illegible] and of field
operations; [illegible] [illegible] enable
[illegible] [illegible] will reduce
the position [illegible] [illegible] the
[illegible] [illegible] [illegible]
[illegible] [illegible] the tracts
[illegible] [illegible] demand.
On such foundations, we must
be satisfied with a general
[illegible], exhibiting in
as much detail as possible the
[illegible] [illegible] the branches are
[illegible], and the most available
method of obtaining those objects
[illegible] [illegible] the data which
are in our possession. The
[illegible] of [illegible] the general
[illegible] of the country, and the
[illegible] supply of water being
given, the capacities [illegible] for
Excavation and Bridge [illegible]

ways [illegible] determined;
but are [illegible] limited to
[illegible] particular points. I
shall, however, in the present
Report, [illegible] laid down
[illegible] and [illegible] enter into
a description of the individual
works above referred to. These
consist of –

I The Futtehgurh Branch
II The Bolundshuhur Branch
III The [illegible]

I. The Futtehgurh Branch

This is a Branch intended for the irrigation of the country lying between the East [illegible] and the main line; its point of departure is situated at the 180th mile of the main Canal, near the village of Nanoo in the Allyghur District. The head works are designed with regulators both across the main Canal itself and the branch, a 1st class [illegible] in connection with these works, and the Station is one of the main posts on the Canal.

The maximum volume of the Futtehgurh Branch is 1250 cubic feet per second, on an estimated length of 160 miles. Of this length [illegible] miles at the head [illegible] under the influence of the irrigation from the Main

[illegible] the [illegible]
distributed [illegible] supply
[illegible] deducted, [illegible] vertical
[illegible] column being calculated
for the greatest [illegible] remain-
ing 162 miles at the rate of
[illegible] feet [illegible] mile.

It is proposed that the
Entire [illegible] reaching
the 164 [illegible] shall be continued
[illegible] extinguish-
[illegible] sous
[illegible] that place with the
[illegible] canal, and thereby to
[illegible] advantages of water
[illegible] it may be
[illegible] to build a
series of [illegible] into
[illegible] way
[illegible]
[illegible]
[illegible] there are
[illegible] a large
[illegible] they may
[illegible] build a
public [illegible].

[illegible] proposed [illegible]
[illegible] of the [illegible]
[illegible] State,
[illegible]
[illegible] country
[illegible] the name ~~Trunk~~ [illegible]
[illegible] TWO [illegible]
[illegible] lengths
[illegible] ded.
[illegible]
[illegible] vertical
[illegible] keeping
as [illegible] as possible upon the
[illegible]
[illegible] from [illegible] at

a

distance [illegible] reported [illegible]
[illegible]
Road [illegible]
the [illegible] portion of the [illegible]
[illegible] raised [illegible]
grade [illegible]
along the [illegible]
[illegible]
The [illegible]
[illegible] 125
miles ~~[illegible]~~ [illegible]
a [illegible]
[illegible]
[illegible]
[illegible] the [illegible]
direction of [illegible]
[illegible]
[illegible]
[illegible] of [illegible]
[illegible]
of [illegible] has [illegible]
[illegible]

[illegible] reports that
"[illegible]
"[illegible]
"[illegible]
"[illegible]
at the 155th [illegible]
"[illegible]
"[illegible]
[illegible]
"[illegible]
"[illegible] that <u>it has</u> [illegible]
"along [illegible]
"[illegible] <u>it</u>
"[illegible] is [illegible] ~~[illegible]~~
"[illegible]
"[illegible]
"[illegible] at the
155th [illegible]
[illegible]

[illegible]

1st	11 [illegible]	2	3	1055 [illegible]	110[illegible]
2	1[illegible]	3	3	105[illegible]	113 6
3	[illegible]	[illegible]	3	105[illegible]3	16[illegible]
4th	5[illegible]	[illegible]	3	105[illegible]	1[illegible]4
5	[illegible]	3	3	1[illegible]6[illegible]9	9 4
6	33	3	3	1[illegible]5[illegible]6	[illegible]40
7th	[illegible]	3	3	1055[illegible]6	7[illegible]4
8	71	[illegible]	3	705.64	6[illegible]
9th	[illegible]	5	3	[illegible]00 2	[illegible] 6
10th	11[illegible]	[illegible]	3	705 2	3[illegible] 5

[illegible]

389

Area = 456
12
5472
89411
5472
547
219
44
4
h = 62.91

62 3.38048
62 3.37676
352
19
5168
35
3203
3.37696
log 91 3.38016
$\bar{3}$.13679
.51695
3.288
.202
h = 3.086

Perimeter
= 70 + 2 × 6√2
= 70 + √288
= 70 + 16.97056
= 86.97056
= 11498

6 = 4224
42 √ 66212
144
.66359
6 = 4224
4000 1.78273
129
4224 1.78402
log 12 1.07918
2.86320
$\bar{3}$.13679

63 42
42
1226
745
1471
537
42
1074
215
1289

63 172.429
.202

3.086
654
12344
1543
185
1407.2 = Disch.

P. 389.

Area 426
12
5112
221
5112
1022
102
R = 62.36

352
63
1056
211
1267
3.37696
3.37823
$\bar{3}$.13679
.51502
3.274
.201
3.073 = V

Perimeter = 65 + √288
= 65 + 16.970
= 81.970
= 1/122

2427
2409
20
63
72
12/ 2416
.201

3.073
624
12292
615
184
1309.1 = Disct.

III Area = 396
12
4752
2971
4950
428
42
6174

L 357
47
2499
143
2642
3.37339
3.37603
$\bar{3}$.13679
.51282
3.257
.200
3.057 = V

Perimeter = 60 + 16.970
= 76.970
= 1/1292

2.409
2.389
20
47
140
2389
12/ 2.404
.200

3.057
693
9171
2751
183
1210.5 = Disct.

C 389

Area 366
12
4392
59831
4392
1318
351
39
2
61.02

357 × 7

3.37349
2.37166
3.1.617

5039
663
9117
1823
182
11122 = Raind

Perimeter 55 + 16.970
= 71.970
= 1/13895

2.407
2.387
.020
12/2.389
.199

Area 336
12
4032
23741
4032
1612
363
17
1

364
12
728

356775
2.37051
3.1.2677

3.018 = V

Perimeter
= 50 + 16.99
= 66.99

2.387
2.369
.020
12
.004
12/2.375
.198

3.018
635
9054
905
181
10140

Area = 276

12

3312

355.71

3312

1318

166

17

1

376

41

376

3.36227

3.36282

3.13677

.49961

3.159

194

2.965 = √

Perimeter = 40 + 16.97

= 56.97

17533

12/2.329

194

2965

672

5930

2076

178

818.4 = Area

Area = 246

12

2952

2.4791

2952

2657

59

12

1

△

3120

32

.335046

3.125

184

2.9 = √

Perimeter = 35 + 16.97

= 51.97

4. 14/3.308

292

276

12/2.208

184

2.937

642

5878

1176

176

1230 = Area

1589

Mean = 216 | Rec = 30 + 16.97
12 | = 46.97
2592 | = 1 / 2.129
2212 |
5184 | 2288
259 | 2.267
52 | 021
23 | 81
55.18 | 4
397 | 12/2.271
31 | .189
397 |
318 |
715 |
335095 | 2.870
33161 | 612
313679 | 5780
4884 | 289
3.079 | 173
189 | 6242 = [illegible]
2.890 |
2.890 = ✓ |

Mean = 186 | Rec = 25 + 16.97
12 | = 41.97
2232 | = 1 / 2.3827
2232 |
4464 | 2246
670 | 2225
178 | .021
4 | 77
5.316 | 003
411 | 12/2.228
71 | .186
411 |
355 |
177 |
331262 | 2.833
339214 | 681
313672 | 2833
47993 | 2266
3.019 | 170
186 | 5269 = [illegible]
2.833 = ✓ |

P. 389

Area = 156
12
1872
94072
3744
1310
7
50.62
437
26
7622
87
2709
332960
3.33231
3.1(77)
46910
2.945
181
2.764 = V

Perimeter
= 20 + 16.97
= 36.97
= 27049

2.182
2.160
.022
26
14
12/2.174
.181

2.764
651
2764
1382
166
451.2

Area = 176
12
1512
97213
4536
151
30
11
1
4729
464
92
928
418
1346
331596
3.31731
3.136(77)
45410
2.845
125
2.670 = V

Per. = 15 + 16.97
= 31.97
= 31279

2.116
2.093
.023
92
046
21
6.7
12/2.100
175

2.670
621
2670
534
160
336.4

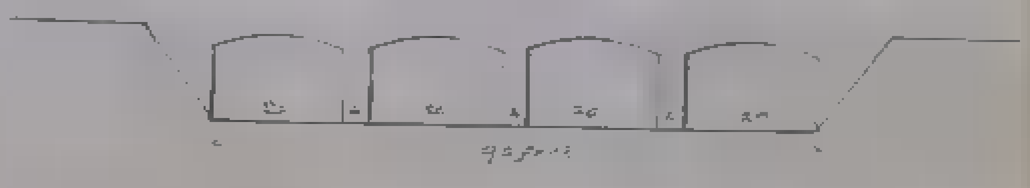
has its lowest [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] plate
No. XXXIII [illegible] [illegible] [illegible] [illegible] shows
the [illegible] in the [illegible] [illegible] of
[illegible] [illegible] [illegible] [illegible]
numbers at this particular
point, must be [illegible].

[illegible]

—	[illegible]			[illegible]			1?40
1	[illegible]	10"	6??	456	3·0?	[illegible]	1?00
2	[illegible]	?0"	62?	426	3·?8	1312·08	1120
3	[illegible]	30"	61·7	39?	3·07	1215·72	1040
4	[illegible]	40"	61·0	361	3·04	1012·54	960
5	[illegible]	?0"	60·2	331	3·02	101?·72	?80
6	[illegible]	70"	??·1	?76	[illegible]	[illegible]	7?0
7	[illegible]	?0"	5?·76	?46	[illegible]	7??	?60
8	[illegible]	110"	55	?16	[illegible]	[illegible]	400
9	[illegible]	130"	53	1??	[illegible]	[illegible]	?40
10	[illegible]	150"	51	151	[illegible]	[illegible]	80
11	[illegible]	1?0"	47	1??	[illegible]	[illegible]	0

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
piers

Fig. LVI.



So to Mr. Brunton
[illegible] Hill

C1

C2

the [illegible] feet [illegible] is [illegible] 11 [illegible] and [illegible] [illegible] of [illegible] is adopted.

Fig: LXII

The [illegible] the [illegible] than [illegible] feet [illegible] [illegible] from the [illegible].

[illegible] the [illegible]

[illegible] 70 [illegible] the [illegible] the [illegible] feet [illegible]

[illegible] 70 [illegible] the [illegible] the [illegible] feet [illegible] [illegible]

[illegible] that [illegible] feet [illegible] the [illegible] which up to the present has been

6

[illegible] gradually [illegible] [illegible].

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	150
[illegible]	[illegible]	[illegible]	[illegible]	560
[illegible]	4 [illegible]	[illegible]	33[illegible]57	400
[illegible]	5 [illegible]	[illegible]	17[illegible]5	340

Beyond this the [illegible] is [illegible] with [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible], [illegible] the [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible].

[illegible] [illegible]

[illegible]

[illegible] well improved [illegible]

[illegible] along the Towing Path [illegible]

[illegible] 25 [illegible] 3 [illegible]

[illegible]		[illegible]	[illegible]
3	[illegible]	70	70·00
6	—	70	70·00
9		70	70·00
11	Falls		69·50
12	—	70	69·50
15		70	69·50
18	Falls		66·00
21	Bridge [illegible]	60	64·5
24		60	63·0
25	Falls		62·5
27	Do	60	61·5
30	— Do	60	60·0
32	Falls		59·0
33	— Do	60	58·5
36	— Do	60	57·0
37	Falls		56·5
38	Do	60	55·5
42	Bridge of [illegible] Channel	50	52·0
45	— Do	50	52·5
48	— Do	50	51·0
47	— Do	50	49·5
52	— Do	50	48·0

✕ Note. In determining the position of the Towing path passages, the [illegible] [illegible] from [illegible]) [illegible] to place it on the outside (or close to) of the [illegible] of the [illegible] of the [illegible] & the [illegible] the passage (vide Fig 2 Diagr XVII [illegible])

[illegible] the Dimensions given [illegible] Channel [illegible] to the width of [illegible] the [illegible] way & the [illegible] the passage.

approximation to the impost blocks of the abutment [illegible] express the work [illegible] [illegible] [illegible] from careless [illegible] building

on the [illegible]

[illegible]

[illegible] to Bridge[illegible]

[illegible]

[illegible] the [illegible]

[illegible] of the [illegible]

[illegible] establish[illegible]

[illegible]

[illegible] for the [illegible]

[illegible]

[illegible]

[illegible]

5	[illegible]	[illegible]	[illegible]
10	[illegible]		12
15	[illegible]		12
20	[illegible]		11
25	[illegible]		14
30	[illegible]		[illegible]
35	[illegible]		[illegible]
40	[illegible]		[illegible]
45	[illegible]	[illegible]	[illegible]
50	[illegible]		11
55	[illegible]		[illegible]
60	[illegible]	[illegible]	[illegible]
65	[illegible]		[illegible]
70	[illegible]		[illegible]
75	[illegible]		[illegible]
80	[illegible]	[illegible]	20
85	[illegible]	[illegible]	[illegible]
90	[illegible]		14
95	[illegible]		[illegible]
100	[illegible]		[illegible]
105	[illegible]	[illegible]	[illegible]
110	[illegible]		16
115	[illegible]		16
120	[illegible]		10
125	[illegible]		10
130	[illegible]		11
135	[illegible]		14
140	[illegible]		15
145	[illegible]		11
150	[illegible]		[illegible]
155	[illegible]		[illegible]
160	[illegible]		[illegible]
165	[illegible]		[illegible]
170	[illegible]		23
175	[illegible]		[illegible]
180	[illegible]		26
185	[illegible]	[illegible]	19
190	[illegible]	[illegible]	14
195	[illegible]	[illegible]	[illegible]

The Canal [illegible] already [illegible] works [illegible] at the 160th mile [illegible] point where the [illegible] is [illegible] feet [illegible] the [illegible]. At the 160th mile, and at that point [illegible] the canal [illegible] purposes [illegible] the [illegible] is the [illegible] with [illegible] Canal [illegible] in 1833 [illegible].

From the above [illegible] point to the Town of [illegible] the distance may be estimated at [illegible] miles, and the [illegible] at that place 634.16 feet. [illegible] distance [illegible] [illegible] of 2 feet [illegible] 43 feet [illegible] inches [illegible] the 160th mile of the [illegible] with the Town of [illegible], and [illegible] with [illegible].

[illegible] that the whole [illegible] of [illegible] of [illegible] that [illegible] them, [illegible] sufficiently [illegible] the [illegible] in the [illegible] and

Rock Harbour; around the east-
ern extremities [illegible] and
towards [illegible] around
the [illegible]
the [illegible] the ground [illegible]
[illegible] proposed [illegible]
[illegible] Isle; [illegible]
[illegible] at the [illegible]
[illegible] post, [illegible]
[illegible] the [illegible]
[illegible]
[illegible] and the [illegible]
[illegible] plainly
[illegible] the [illegible] condition of
the [illegible] the construction of
[illegible] now [illegible]
[illegible] the [illegible]
[illegible].

[illegible] general [illegible] of the
country [illegible] the [illegible]
and [illegible] the [illegible] to-
gether with [illegible]
[illegible] East [illegible],
(the [illegible] boundaries of
the [illegible] and the
[illegible]
[illegible]) will be [illegible]
[illegible] the [illegible]
as well as by a [illegible]. This
Map [illegible] XI [illegible]
a [illegible] to
the [illegible] as proposed by Mr.
Head [illegible]
have to [illegible] the [illegible] con-
nection with this subject.

[illegible] Head [illegible]
the road at [illegible] with the [illegible]
[illegible]
on a direct course to the end
of the [illegible],
the bearing is a few degrees to
the

the bank of the [illegible] the distance 13 miles, at the [illegible] from the [illegible] of [illegible] the district of [illegible] the [illegible] the [illegible] a distance of 56 miles almost due South to the village of [illegible] among [illegible] the [illegible] of [illegible] [illegible] the [illegible] the village of [illegible] [illegible] mile of the [illegible]

On the [illegible] of the above [illegible] collection of the [illegible] of the East [illegible] [illegible] the village of [illegible] and [illegible] of [illegible].

From the village of [illegible] the [illegible] has an inclination of about 2 degrees to the East bearing to other reasons upon the direction of the Ganges, so as to save the [illegible] of an extensive line of [illegible] under the same [illegible] commences almost on the right bank of the Ganges, [illegible] flows into the East [illegible] the boundary of the [illegible] to avoid as much as possible the [illegible] of nullahs connected with the Ganges, and to [illegible] with the [illegible] with which it is connected [illegible] passing between [illegible] and the Ganges at [illegible] as possible to the latter and [illegible] about 94 miles in which distance [illegible]

of the [illegible]

[illegible]

II ... III [illegible]

[illegible]

vol. 1
Pt. II
chap. III

2 D 8 26

at: [illegible]

[illegible]

[illegible] projected [illegible]

[illegible]

Diag: LXIII.

[illegible] AC [illegible] BC [illegible] C, [illegible] D [illegible]

[illegible]

AC [illegible]

BC [illegible]

CD [illegible]

[illegible]

[illegible] C [illegible]

A [illegible]

B [illegible]

C [illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible] 10	[illegible]	4·97
[illegible] 17	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	5	
[illegible]	4·97	
[illegible]	[illegible]	
[illegible]	10·12	
[illegible]	[illegible]	
[illegible]	110·0[illegible]	4·97
[illegible]	4·97	
[illegible]	110·6[illegible]	

[illegible] 19·15 [illegible]

[illegible] 3 [illegible]

BC

[illegible] 1·50 [illegible]

[illegible]

[illegible] (1·1254 ·220 [illegible])

1·27 [illegible] It is proposed [illegible] the proprolongation of the [illegible] from the point C to the 80th mile [illegible], as the [illegible] meets that of [illegible] at the point C [illegible] the [illegible] of the [illegible] the [illegible] (Diagram [illegible]). The [illegible] in 80 miles is ([illegible]) [illegible] feet. It is [illegible] given depth of [illegible] in Diagram LIX, it may [illegible] of this [illegible] works [illegible] of the subject in an [illegible] point of view, to leave [illegible] adjustments.

[illegible]

[illegible]	[illegible]
[illegible]	10 [illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	10 [illegible]

[illegible]

[illegible] the total [illegible] distance [illegible] also [illegible] may [illegible]

[illegible] to the [illegible] points [illegible]

[illegible] in a [illegible]

[illegible]

[illegible]
is [illegible].

~~[illegible]~~ [illegible]
[illegible]
[illegible]
[illegible] to [illegible] wood & ironwork [illegible] ed.
~~[illegible]~~ [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] Trusts
[illegible]
[illegible] by following this rule also
[illegible]
[illegible]
[illegible]
[illegible].

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

I. [illegible] equal to [illegible]

II. [illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible] (3)

Diag: LIX

[illegible]

the furnishing of Irrigation,

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[illegible] [illegible] [illegible]
district would be placed [illegible] an
[illegible] with [illegible] [illegible] with
[illegible] the [illegible] and
[illegible] the [illegible] [illegible],
[illegible] [illegible] parts, and
the distant [illegible] [illegible] lands
[illegible] [illegible] be adapted to
[illegible], so that rafts or boats
[illegible] [illegible] point [illegible]
[illegible] [illegible] [illegible]
[illegible] possible, [illegible] matter
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] with a navigable [illegible]
[illegible], taking [illegible] the [illegible]
[illegible] [illegible] [illegible]
[illegible] two [illegible] objects
[illegible] be attained 1st the
[illegible] of [illegible] during
floods, and 2nd the means
of [illegible] the [illegible] and
with [illegible] by a navigable
line, also [illegible] point [illegible]
[illegible] the [illegible] river joins
the [illegible] [illegible] perhaps
[illegible] [illegible] navigation
than that which you sug-
-gested [illegible] the [illegible]
[illegible] [illegible] [illegible]
and [illegible] the [illegible] near
the [illegible] Bridge
2. the [illegible] connection
with the [illegible] would be
[illegible] whole course by a well
regulated [illegible] Canal, in
the [illegible] [illegible]
[illegible] [illegible], by the
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]

[illegible] ~~[illegible]~~ distinguished [illegible]

P. 571 in continuation of Text

— Before closing this Chapter I may in ~~justice to my successor~~, draw attention to the comparatively imperfect Data upon which the original Estimates for the Branches had necessarily to be formed. ~~In the imperfect knowledge of the details of surface and extent to which the resources of the land might be applied~~ This will be gathered from the opening Paragraphs ~~of this chapter~~ where explaining that even at the closing of my reports in 1853/54 I have been unable to lay down the same definite views as to detail that accompanies my description of the Main & Terminal lines. Since the period when the Estimates were drawn up ~~[illegible]~~ much ~~[illegible]~~ information has been obtained not only of the topographical features & contour ~~of the~~ but of the demands & resources of the Country, [illegible] this information ~~[illegible]~~ in all its successive developments ~~in the details~~ has at every step given increased confidence to the views which I had formed, as to the value of these ~~branches~~ subordinate works. Whatever the increase of expence may therefore be found in that of the [illegible] Branch if my views are carried out, they will be [illegible] this increase will be met by a proportionate return to the outlay expended, and by increased benefit & accommodation to the trade & agriculture of the Country.

CHAPTER. IV.

[illegible]

[illegible] nearly [illegible] examined [illegible]

573

[illegible] to ministers in those times [illegible]

[illegible]

57½

.. the Traditions of the inhabitants .the Delhi & adjoining Districts handed .own from Father to Son had invariably .presented these old mounds as the .mains of Rajbuhas, this name .as assumed by us altho perhaps .ith a more specific application.

.o illustrate the relation of the Rajbuha .the Canal itself in the system of Irrigation .dopted in the North West Provinces of .ndia in a manner which will be fa= .miliar to most readers, the details of .e method of supplying the population .f Towns & Cities in Europe with water .ay be referd to. In the latter the .ater is [illegible] in the reservoir from .ence it is carried to the outskirts of .e Town in the "mains" or great supply .ipes: from these it is led through the .ifferent streets in the "Distributary pipes" .nd the wants of individual houses .re met by a system of "Service pipes". Now in our Irrigation system, the .runk & Terminal lines with the .reat branches play the part of the .eservoir: the Rajbuhas hold to .hem the relation of "Distributary .ipes" and the village water courses .present the "Service pipes" in the .isposal of the supply in detail. The .ajbuhas is [illegible] the connecting .nk between the supply & the ser= .ice channels & it is from it alone .at the process of distribution is .arried on;

[illegible]

[illegible]

what

[illegible]

sink

[illegible]

sources

[illegible]

[illegible]

[illegible]

1st [illegible]

2nd [illegible]

3rd [illegible] the product [illegible]

4th [illegible]

[illegible] use [illegible] the [illegible] the method by which the greatest portion

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[illegible] of this irrigation is effected.
The imperfections of the 1st are
[illegible], they embrace a range
of [illegible] bodies, those of land
[illegible] in the expenditure
[illegible] the [illegible] conditions
of [illegible] Establishments, for
the [illegible] measurement
of land irrigation. They lead
to [illegible] interference on
the part of the [illegible] Establish-
ment with the domestic details
of villages, and, from the com-
plication of the [illegible]
relations [illegible], they [illegible] to
[illegible] returns [illegible] so far that
[illegible] tenure is due,
[illegible] the [illegible]
and the [illegible] has been assum-
ing [illegible] the measurement practi-
cable to measure it; the whole
system is bad, as one [illegible] unneces-
sary [illegible] and uncalled
for meddling in details; but
bad as it is, it has been much
easier to recognize the imper-
fections, than to [illegible]
[illegible] system [illegible]
[illegible] framed [illegible]
the irrigator is not [illegible]
use of the water, but the trouble
and expense [illegible]; the
water, therefore, is [illegible],
and the [illegible] not [illegible]
[illegible] between [illegible]
[illegible] pressing
[illegible].

The 3rd method, is an
improvement on the 1st; the
[illegible] principle as that [illegible]
described

described; but with a varying supply of head water in the Canal, it is quite impossible, as well as attended [illegible] with [illegible] to [illegible] the [illegible] quantity of discharge. The [illegible] has have been thought that the [illegible] uses out of the [illegible] more water than was bargained for, and the results have been so unsatisfactory, [illegible] the utmost [illegible] have [illegible] to [illegible] the water [illegible] misappropriation, that the plan described [illegible] frequently [illegible]; the method, however, is so [illegible], that the transaction is one of [illegible], without any [illegible] details.

[illegible] method [illegible] plan [illegible] in the true [illegible] by which water ought to be supplied to the cultivators, [illegible] between the parties on the [illegible] which the [illegible] of the water is [illegible] to the [illegible] the value of the water is [illegible] to the [illegible].

[illegible] the cause of the [illegible] system [illegible], it [illegible] as [illegible], to [illegible] it [illegible]; because of this [illegible] arises in great measure from the [illegible]

and

[illegible] the position of the [illegible]
[illegible] as to
the area of ground that will
be irrigated from [illegible], having
[illegible], as well as to
[illegible] equate
[illegible]
[illegible]
[illegible]
[illegible] the supply
[illegible]
[illegible] in all probability,
[illegible]
[illegible]
[illegible]
[illegible]

This [illegible],
[illegible] considerably
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] a variety
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] additional
[illegible]
[illegible]
[illegible]

[illegible] ground [illegible]

[illegible]

[illegible] measures as

was

[illegible] equally [illegible] of the [illegible] and the [illegible] adjacent [illegible] the distribution [illegible] the distribution of the water [illegible] acquired.

It is [illegible] and [illegible] equally distributed, and [illegible] such limits [illegible] discharge [illegible], that we have to [illegible] a [illegible] and economical [illegible] supply [illegible] introduced, the results [illegible] equally satisfactory, [illegible] obtain [illegible] a [illegible] approximation to the quantity of water which is required for the irrigation of [illegible], or which is adapted to the wants of individual estates. To [illegible] the true value of the property that is held for distribution, and [illegible] that property [illegible] community, are the great [illegible] all [illegible]

In

[illegible]
just [illegible]
on the [illegible] of the
Sovereign [illegible]
with the [illegible] and Commander
and Piedmont, [illegible] any other
[illegible] already
that [illegible]
[illegible] for many
years had [illegible] to the
idea of [illegible] regulation
in those provinces, was adopted
by the [illegible] Division in the
East India [illegible]
to [illegible] and Piedmont [illegible]
[illegible] other
and the [illegible] States. —

The results of Major [illegible] and
Smith's visit to Italy, [illegible]
[illegible] for some time before the
public, [illegible]
[illegible] of [illegible] irrigation,
and [illegible] as in suggestive
remarks [illegible] the
[illegible] adopted in the Irrigation
and the [illegible] in those
[illegible] as compared with
that in the Magn. Establishment
Canals in Italy. — [illegible]
is in fact the [illegible]
our operations must [illegible]
be guided, and it will, [illegible]
its ancient [illegible] a
complete reorganization of
our System. —

With [illegible] suggestions
[illegible] allusions
on the [illegible]
in regulating the supply of
water as [illegible] distri-
-buted

water, the [illegible] [illegible] by the Trustees
[illegible] appropriations, [illegible] they
[illegible] upon this subject
all the [illegible] that could possibly
be expected [illegible] the [illegible] that
the [illegible] [illegible] [illegible] have
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
induced [illegible] to adopt the same
plan [illegible] [illegible] in the
[illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] which
the water for irrigation will
be supplied to the Counties with
the exception of [illegible] these
[illegible] [illegible] that [illegible]
immediately [illegible] with the
[illegible] and [illegible] [illegible], will
[illegible] [illegible] [illegible] to
the [illegible] [illegible] [illegible] the
[illegible] [illegible] this act
[illegible] [illegible] in the form
of [illegible] [illegible], of
sufficient capacity to admit
of [illegible] [illegible] or [illegible]
of [illegible] that may be [illegible]
to [illegible] on [illegible]
[illegible]. As the capacity of
[illegible] [illegible] is in all cases
[illegible] to be [illegible] with
a height in proportion, there will
be ample room for the purpose.
[illegible], it may be stated, adopt-
ed a [illegible] [illegible] capable
of admitting any form of mo-
[illegible] [illegible]; my aim
having been to give full scope
for [illegible] of area & opening,
but to avoid the evil of alter-
-ation and [illegible] [illegible] of
the original work, [illegible] [illegible]
[illegible]

[illegible]

[illegible]

[illegible] F?, 4.55; 1.1.; M.2; ch. [illegible]

[illegible]

[illegible]

~~Major~~ Capt. A. G. Goodwyn of the Bengal Engrs the Ex. Eng. of the N. Divn of the Ganges Canal works

On my ~~leaving charge of the works~~ departure from Roorkee in April 1854, I left ~~Capt.~~ Capt. A. G. Goodwyn of the Bengal Engineers, Ex. Eng. N. Divn G. C. works, engaged in experiments on discharges with reference to a plan for a Module ~~[illegible]~~ which he had designed; the ~~[illegible]~~

~~[illegible]~~ apparatus by which he proposed to secure uniformity of discharge was simple, by the action of a cam in a circular orifice, the action being regulated by ~~[illegible]~~ a float appended to

[illegible]

the time by a lever – Capt Goodenough had
the full use of the workshops, and [illegible]
for expending money to any reasonable amount in
completing his experiments – ~~From~~ Some time before I
left Bombay, Capt. G. had succeeded in obtaining
discharges in fair time very accurately, and unless
the machinery with which the regulation must
necessarily be encumbered is of too delicate or complicated a
nature, I look with sanguine hopes to a
successful termination of his labors,
The delay that has attended the publication of this
report, has enabled me to place in Appendix
Capt Goodenough's paper on his module which he has
been kind enough to send to me, with permission to
publish it. I have alluded to this paper in my Preface.

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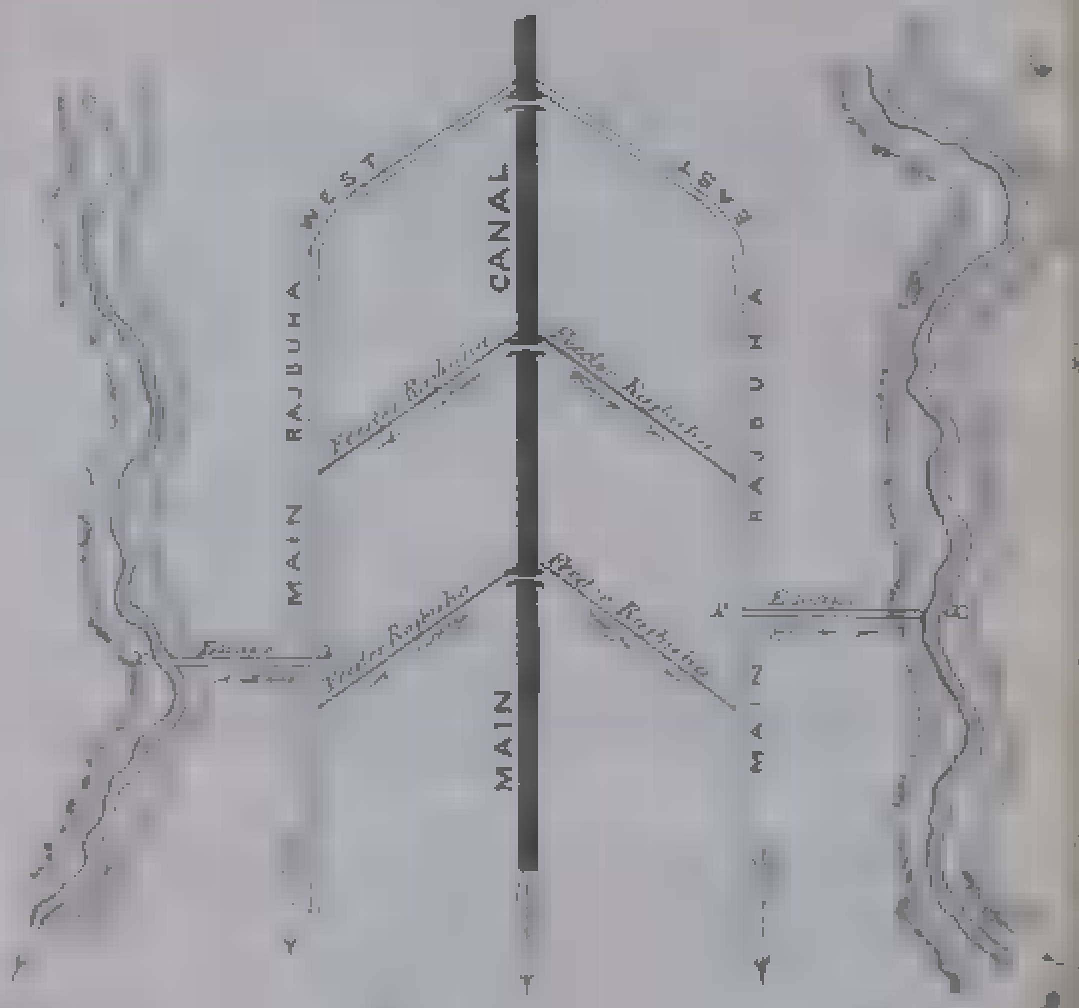

[illegible]

2nd [illegible]

[illegible] distribution of the surplus [illegible] Ens[illegible]e [illegible] security [illegible] by a [illegible] relief [illegible]

[illegible] by [illegible] mostly [illegible] the [illegible] must [illegible] [illegible] [illegible] the [illegible] in part [illegible] [illegible] the [illegible] without [illegible] [illegible] [illegible] [illegible]. 9th [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] and then [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the supply [illegible] and the [illegible] being [illegible] waste pipes. 2d [illegible] [illegible] [illegible], and if the [illegible] [illegible] [illegible] [illegible] are [illegible] adjusted it is supposed that the [illegible] [illegible] [illegible] would [illegible] to the [illegible] of [illegible] [illegible] [illegible] to the [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] for the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Baths [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] on the supply of water [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] and [illegible] [illegible] on the [illegible] [illegible] beyond it, as far as the [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] part of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] above

[illegible]

5/4

[illegible] part. This [illegible] [illegible] the [illegible] occupied by the [illegible] of the [illegible] at the [illegible] the [illegible] the [illegible] of the [illegible] of the [illegible] to the distribution of the supply [illegible] situation between the [illegible] of the [illegible] a quantity of water for [illegible] purposes. [illegible] may be necessary [illegible] the original project for supply.

The [illegible] which [illegible] are [illegible] may be classed under three denominations.—

I. The [illegible] the natural [illegible] arising from the proximity to the [illegible] at a minimum [illegible]

II. [illegible] between [illegible] and the [illegible] at the [illegible] in the greater part of which [illegible]

(Continued).

country, the [illegible] heads
are well situated for the heads of
the Canal.

III. From the [illegible] ... [illegible]
[illegible] heads are the usual
[illegible] having 13 [illegible]

I. I have selected two
heads for supplying irrigation
on this bank to the [illegible] out-
let [illegible] escape, and to the Barad-
[illegible] [illegible]. The former is
placed in such a position in
proximity to the channel of the
Ganges, that it may be used
either for escape, irrigation, or for
mills, without any [illegible] of its
being [illegible] [illegible]. The latter
is [illegible] with the [illegible]
[illegible] of which it forms
a [illegible] part. While the
[illegible] head will be supplying
water for the villages of [illegible],
[illegible], &c. and to the Eastern
portion of the Puttee lands lying
on the [illegible] of the Ganges; that
at [illegible], will complete
the irrigation of the western tracts
of the Puttee [illegible]. From these
two heads in fact any quantity
of water may be taken, and at
the same time an [illegible]
is obtainable from the Ganges
River, should the irrigation of
the Puttee and the neighbouring
lands call for an extraordinary
supply. Although I have se-
lected the heads to [illegible] the
[illegible], there is every facility for
providing the most efficient
means

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means for irrigation on the whole tract lying [illegible] the alluvial(?) [illegible] [illegible]; and the establishment of one or two Regulator heads on the [illegible] [illegible] of the navigable [illegible] would do [illegible] that would possibly be required, beyond this and in the vicinity of the great works at [illegible] and [illegible] [illegible] with the [illegible] and the [illegible], irrigation is hardly required. In the immediate neighbourhood of the Anicut(?), spring water is near the surface, and on the [illegible] ridge, the depth of [illegible] is opposed to its use ~~as a supply~~ for irrigation. At the [illegible] [illegible] of the [illegible] [illegible], however, the [illegible] which [illegible] [illegible] with the cattle [illegible], are [illegible] [illegible] but with [illegible] [illegible] for the irrigation of the gardens and [illegible] both at [illegible] in the neighbourhood of [illegible]; they are in fact [illegible] [illegible] in every respect to the [illegible] that has been universally adopted in the Ganges Canal works, viz. a masonry channel [illegible] into the Canal, with its head in the form of a [illegible] well or Cylinder, in which the water stands to a height equal to that of the Canal high water mark.

II. The [illegible] on this [illegible] as far as the 11th

mile

10th [illegible] to the [illegible] [illegible],
[illegible] [illegible] in the [illegible]
the [illegible] the [illegible] [illegible]
on the Canal [illegible] [illegible],
[illegible]. From the Lawrence Falls
to the [illegible] at [illegible] [illegible]
10th [illegible] [illegible] [illegible] water [illegible],
and [illegible] in the immediate
vicinity of the Falls; as [illegible]
and [illegible], it practically exists;
Heads [illegible] as [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] well [illegible]
At the [illegible] [illegible] and
[illegible], at the head and
tail of a long [illegible] of [illegible],
[illegible] the country which is
[illegible] [illegible] [illegible],
[illegible] [illegible] of the [illegible]
Heads, [illegible] down [illegible]
[illegible] with the Canal bed,
[illegible] [illegible], 3 [illegible]
higher, [illegible] which has
[illegible] [illegible] [illegible]
for the [illegible] [illegible]; the [illegible]
of water [illegible], at the head of
the [illegible] at [illegible]
and for the [illegible] supply of the
main [illegible] as [illegible],
will be [illegible] [illegible],
will be in direct proportion to
the depth of water in the main
Canal. — A similar remark
applies to that at the Lawrence
Falls, which may be considered
as the head, and the commanding
[illegible] supply of [illegible] of country
comparatively [illegible] which lies
beyond it. — In both the above
[illegible] however, [illegible] by keeping
the floorings of the Heads as nearly
as

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[illegible]

[illegible]

~~[illegible]~~

~~[illegible]~~ them

[illegible] 110th [illegible] that from the 110th [illegible]

" [illegible]

[illegible] state that [illegible] of such works [illegible]

[illegible]

Diag: LXI

[illegible] the designs for these works [illegible] accurately laid down.

[illegible]

Ridge

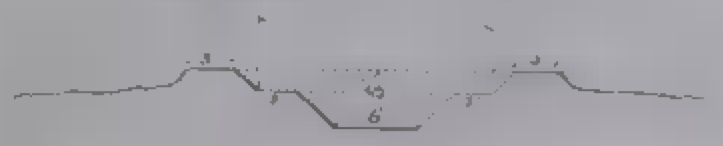
rise between the [illegible] [illegible] [illegible] that [illegible] the 2nd section [illegible] the [illegible] [illegible] the 1st [illegible] [illegible] which the [illegible] may [illegible] [illegible] [illegible] [illegible] than [illegible] [illegible] vertical [illegible] the [illegible] [illegible] the [illegible], elevation [illegible] will be required [illegible] of [illegible] calculating the [illegible] [illegible] [illegible] the first [illegible] descending [illegible] equal to that of the [illegible] [illegible] [illegible] the first [illegible] [illegible] the [illegible] of the first [illegible] descending [illegible], I would [illegible] the slope of [illegible] 1 1/2 [illegible], the [illegible] slope being [illegible] descending [illegible]. I would also [illegible] all the [illegible] the [illegible] and I would [illegible] the [illegible] that [illegible] [illegible] by a [illegible] [illegible] with a [illegible] to three feet.

5th Before [illegible] [illegible] [illegible]

[illegible]

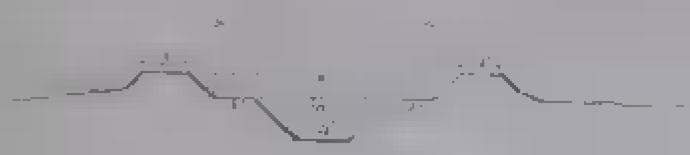
Diag. LXII.

Section on **CD.** *or at the Heads of Rajbuhas and Feeders*



Section on **EF.** *or at the tails of Feeders on their entrance into Rajbuha*

Section on **AB** *on Main Line below 1st masonry descent.*



[illegible]

---

* [illegible]

[illegible] the [illegible] [illegible] the right [illegible].

7 [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible].

9 [illegible] [illegible] [illegible].

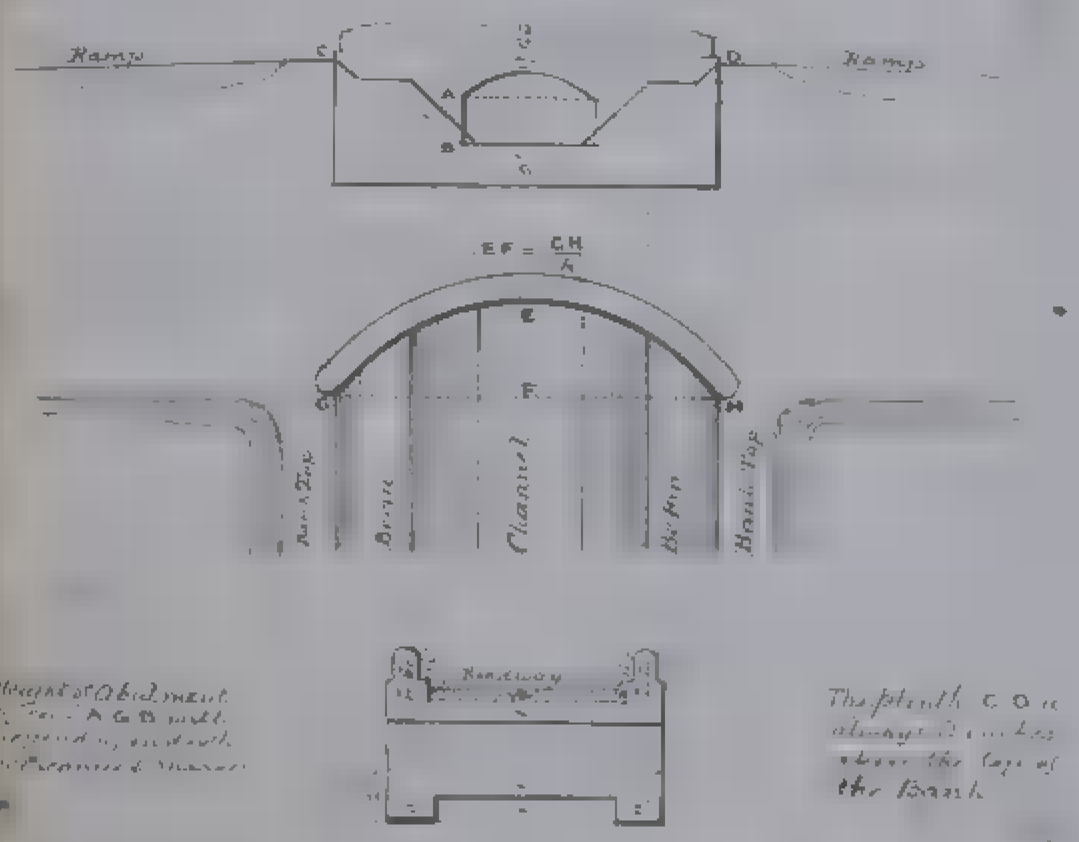
10 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

11 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] well

[illegible]

Diag: LXIII



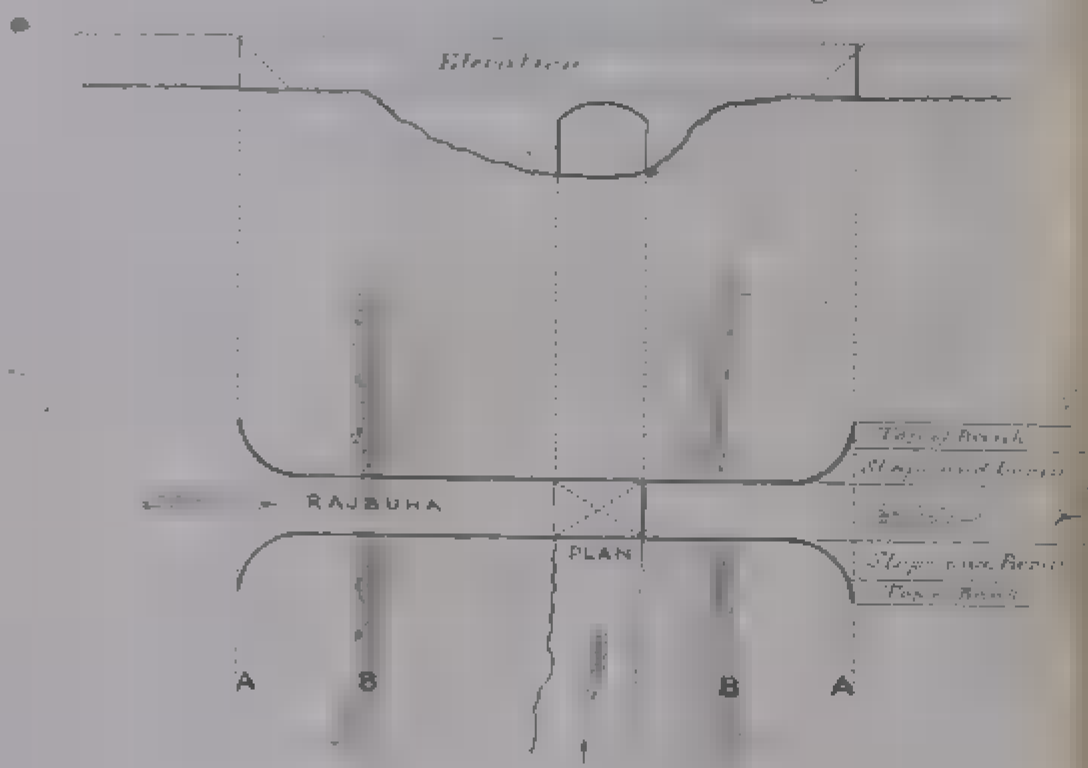
12 [illegible]

13 [illegible]

14 [illegible]

15 [illegible]

Diag LXIV.



[illegible]

A & B. [illegible]

[illegible] the entrance [illegible]

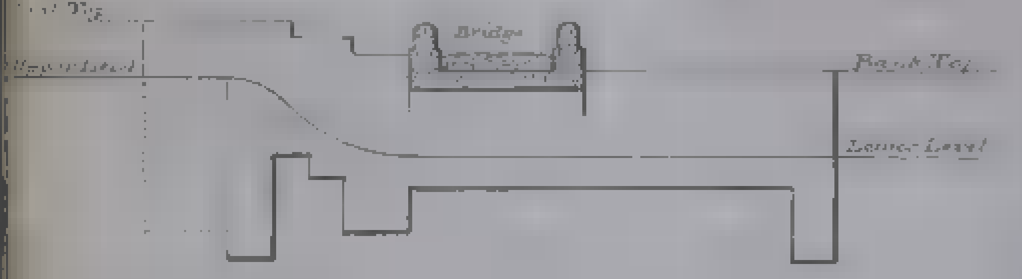
16 [illegible]

17 [illegible] Water [illegible]

18 [illegible]

[illegible]

Diag: LXV

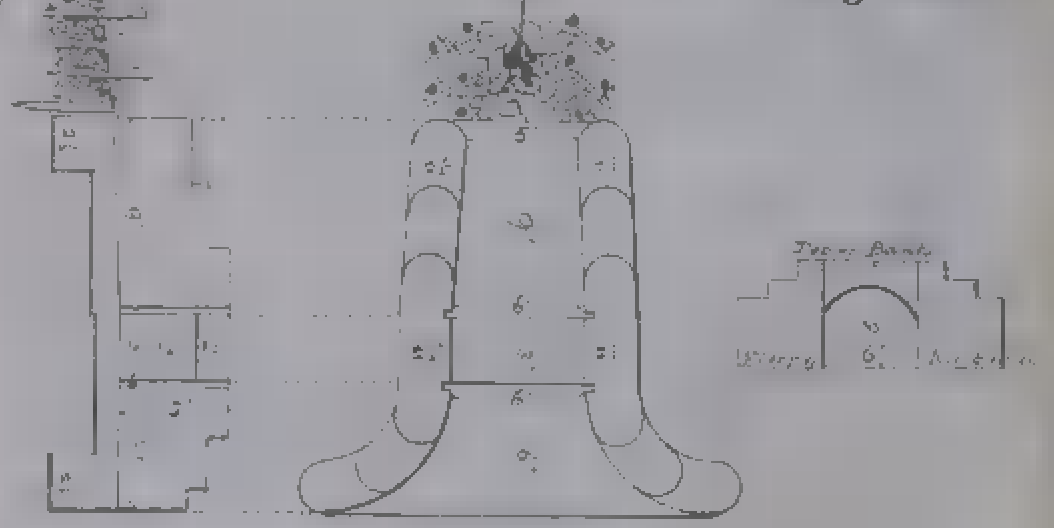


[illegible] account [illegible]

19 [illegible] numerous [illegible]

[illegible] of [illegible] Diag. LXI [illegible] [illegible] [illegible] [illegible] the following plan.

Diag. LXVI.



[illegible] the passage [illegible] always [illegible] stables [illegible] Escarpe [illegible] [illegible] Escarpe [illegible] a [illegible] [illegible] the Scarp [illegible] as possible.

[illegible] the Escarpe [illegible] the [illegible] the Aqueduct [illegible] that the [illegible] will be [illegible] dangerous [illegible] have been [illegible]

"The Scarps [illegible]

19. [illegible] the English [illegible]

[illegible] of [illegible] [illegible] in [illegible] [illegible] [illegible].—

[illegible] the [illegible] [illegible] with the [illegible] [illegible] [illegible] an "Agreement" [illegible] the passage [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]."

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] out the [illegible] [illegible] the [illegible] [illegible] town [illegible], [illegible] [illegible] [illegible] [illegible] looks [illegible] the [illegible] [illegible] [illegible] [illegible] with the [illegible] [illegible] instead of making [illegible] [illegible] [illegible] [illegible] the purpose of [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] complete. [illegible] [illegible] takes the [illegible] [illegible] [illegible] [illegible] [illegible] under the name [illegible] "[illegible]" [illegible] for [illegible] [illegible] [illegible] & in fact makes the [illegible] [illegible] [illegible] "[illegible]" [illegible] [illegible] [illegible]", [illegible] the

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[illegible] Dissipating [illegible]

[illegible] it must be recognised that [illegible]

[illegible] them, call for the strictest economy in money expenditure.

[illegible] 1/60/54 [illegible]

[illegible] that portion [illegible] independently [illegible] by which the [illegible]

[illegible] of the Irrigation [illegible] again to the 110th [illegible]

[illegible] connection [illegible] will be [illegible] the [illegible] [illegible] has been provided [illegible] [illegible] [illegible] throughout the whole [illegible] [illegible] [illegible] of the Canal [illegible] [illegible] [illegible] will [illegible] injurious

In laying out the [illegible] on this kind of country, the most [illegible] features appear to be the passage of the [illegible]

Kalli Nuddee for the purpose of irrigating the [illegible] lands to the right of [illegible] [illegible] the introduction of [illegible] [illegible] [illegible] between [illegible] [illegible] and the East Kalli Nuddee, especially upon that part of it on the [illegible] [illegible] [illegible], and the [illegible] [illegible] these lands.

For all these uses, a leading line might bring the heads of drainage, and be afterwards in addition [illegible] supply by [illegible] means of the [illegible] [illegible] by aqueduct [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] between [illegible] [illegible] [illegible] be provided for all the lands lying between it and the west Kalli Nuddee. [illegible] [illegible] the [illegible] would cross the latter [illegible] by aqueduct, and its [illegible] down the [illegible] lying on the right of the west Kalli, would be [illegible] by a [illegible] [illegible] across the [illegible] [illegible] [illegible]. This [illegible] would [illegible] [illegible] [illegible] [illegible] to the [illegible] channel [illegible] it [illegible], [illegible] addition to the supply that it would give to the west Kalli Nuddee [illegible]. It is doubtful whether for the purposes of aqueduct the existing bridge on the West Kalli Nuddee might in any way be applicable in using the space under the roadway for [illegible] [illegible] waters in the [illegible] of the water channel; the roadways are in all probability

^ altho even in this case the syphon plan of Channel, is an available expedient

[illegible] situated in a [illegible] than that which would be required [illegible] of the syphon channel.^

[illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] through [illegible] through [illegible] Water Supply.

[illegible] [illegible] [illegible] [illegible] [illegible] the 116th [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

From the 116th to the 180th mile or to the Tuscon [illegible] facilities for supplying Water from the main Channel or Reservoirs are given at almost every bridge at every one in fact where such is necessary. At [illegible] of the high land near

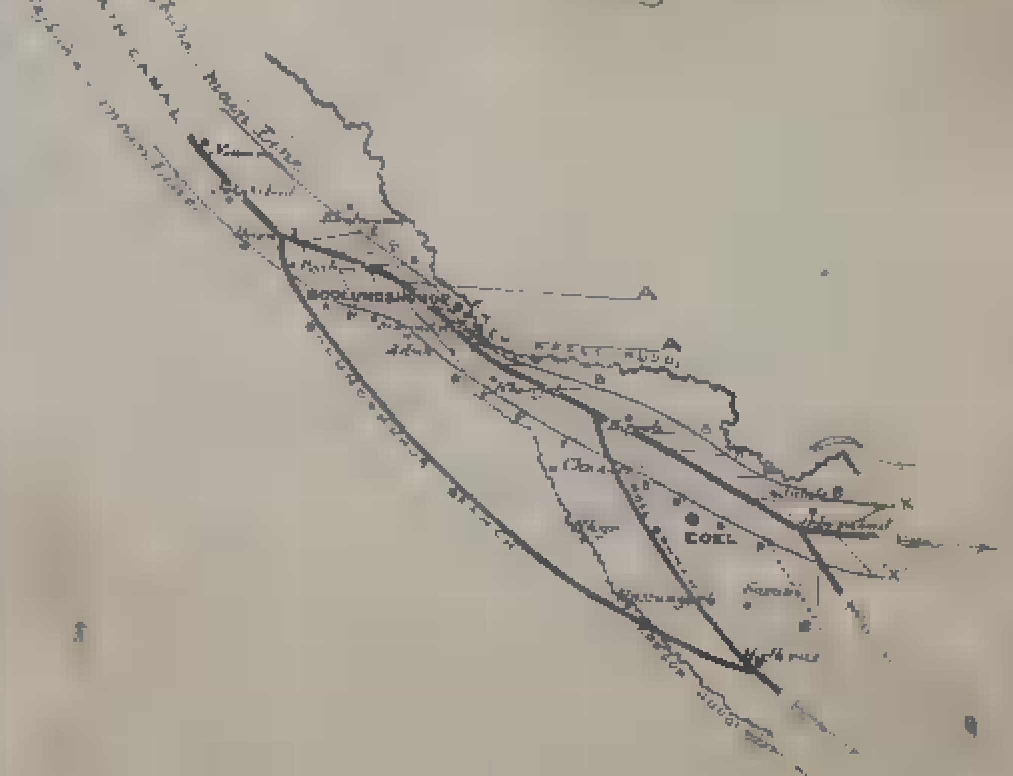
= [illegible]

locking [illegible] at the heads of the [illegible] and [illegible] [illegible] heads situated on the upper [illegible] of the [illegible] [illegible]. The general design [illegible] is similar to those at [illegible] before describing, giving an amount of water for irrigation sufficient to [illegible] [illegible] below [illegible] [illegible] [illegible] in this place, [illegible] to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attached to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] the [illegible] are [illegible] the [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible]. The [illegible] [illegible] being at the [illegible] $1\frac{1}{4}$ [illegible] [illegible]. The [illegible] [illegible] [illegible] passes through a wide [illegible] depressed [illegible] below the surface of the country [illegible] [illegible] [illegible] sufficiently [illegible] to give the fullest [illegible] for [illegible] the [illegible] [illegible] Aqueducts. The works [illegible] [illegible] [illegible] [illegible] Clear [illegible] with [illegible] at [illegible] points of immediate contact with [illegible]. [illegible] on the Eastern [illegible] a Canal of [illegible] so many [illegible]

2 [illegible]

[illegible]



iag: LXVII

[illegible] duty, [illegible] upon [illegible], but I [illegible] that [illegible] these [illegible] the [illegible] made [illegible] in the [illegible] [illegible] for passing the [illegible] [illegible] in the above [illegible] marked AA, and the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] BB. [illegible] BBB [illegible] [illegible] [illegible] presents [illegible] view [illegible] [illegible] [illegible] [illegible] [illegible] Wagons [illegible] [illegible]

country [illegible] planned [illegible] to [illegible] work, and that [illegible] to the [illegible] [illegible] [illegible] to be irrigated by [illegible] [illegible] [illegible] invited to [illegible] [illegible] [illegible] width, [illegible] EBB [illegible] is a [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Chounah [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible], and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Canal [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as X or it would [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the Canal [illegible] [illegible] [illegible] which it would [illegible] [illegible] [illegible] as [illegible] [illegible] [illegible] as O. [illegible] [illegible] [illegible] [illegible] [illegible] at the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] on this [illegible] of the [illegible] would be placed in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] as
BBB [illegible] and BBB on the
[illegible] escapes (the
[illegible] [illegible] the [illegible] [illegible] [illegible]
[illegible] the [illegible] [illegible] the [illegible])
[illegible] [illegible] established at every
[illegible] point. These escapes
[illegible] [illegible] advantage [illegible]
AA [illegible] [illegible] of the [illegible]
[illegible] [illegible] [illegible] [illegible], and
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] as ~~[illegible]~~ [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] the <u>Terminal lines</u>, which
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible], [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] the [illegible] [illegible]
[illegible] [illegible] [illegible], [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible].

III. [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] by the extraordinary
[illegible] which it naturally possesses
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] adapted [illegible] [illegible]
[illegible] [illegible], [illegible] at the same
[illegible], [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] as [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] peculiar ad-
vantages.

[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] these advantages
[illegible] [illegible], but [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] falls down.

[illegible]

wards, [illegible] the [illegible] height of the command [illegible] the [illegible] position [illegible] to give.

The ~~[illegible]~~ [illegible] on the Ka[illegible] Terminal [illegible] Bradford [illegible] situated [illegible] [illegible] at a distance of [illegible] [illegible] the [illegible] thirty miles [illegible] [illegible] of the [illegible] ~~[illegible]~~ [illegible] that is [illegible] [illegible] and the [illegible] from as above the land [illegible] [illegible] ~~[illegible] as the [illegible]~~ ~~[illegible]~~

[illegible] the 30th to the [illegible] mile the width of the [illegible] is reduced to [illegible] and the [illegible] or [illegible] [illegible] the [illegible] [illegible]

[illegible] the [illegible] mile the [illegible] is [illegible] and the [illegible] [illegible] above the [illegible]

[illegible] the [illegible] [illegible] the [illegible] [illegible] the [illegible] is [illegible] [illegible] the ~~[illegible]~~ site and [illegible]

[illegible] the [illegible] of the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the Terminal [illegible].

The [illegible] of the [illegible] [illegible] to the [illegible] neighborhood of [illegible] [illegible] from 12 to 15 [illegible] per mile, the [illegible] portion [illegible] on the [illegible] [illegible] the requisite advantages

from Ordinary irrigation it will be necessary to reduce the slope of the [illegible] to a minimum, which should be a [illegible] inches per mile. This in the first seventy miles of the Branch, would on each mile, give the [illegible] a command over that of the [illegible] from which it was supplied of [illegible] inches. Supposing then that the amount [illegible] of the [illegible] was [illegible] the [illegible] channel must be 9⅓ miles in length [illegible] would [illegible] out before the surface of the country [illegible] the 71st mile [illegible] commands, [illegible] inches [illegible] slope having only [illegible] inches per mile, we [illegible] give [illegible] of command in each mile [illegible] would be necessary to obtain the result [illegible] — With a slope of water in the [illegible] of [illegible] feet [illegible] — The [illegible] length will be reduced in the first case to 5⅓ and in the other to 6 miles. [illegible] the points at which [illegible] or [illegible] with a slope of 5 and 1/2 inches per mile.* [illegible] the very [illegible] and if [illegible]

* At the Kylespur Bridge however the fall of two feet will give increased command to the Rajbaha lying along it: in this case the distance at which the water will be delivered becomes reduced from 5⅓ to 2⅔ miles. Advantages of an equally favourable nature will exist at the 91st mile from whence the water will be delivered at a distance of 5⅓ instead of 8 miles.

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[illegible] supplied from the [illegible], which were very [illegible], scattered over the whole length of the Canal; & irrigation will be obtained with facility on the whole surface of the land which comes under their influence.

Commencing therefore with the top of the Cawnpore Branch ~~line~~, in explanation of the general views that I entertain of the distribution of the Channels. In prolongation of BBB and from its termination X on the above Diagram, I would carry the main ~~line~~ or Eastern [illegible] Rajbaha, as it may be best called, straight forward, keeping it [illegible] the left, and far from the heads of the [illegible] and the lesser Rivers. The former I have before explained lies to the North of [illegible] and [illegible], the latter are situated in the [illegible] of [illegible] road.— The main line would proceed onwards keeping in the most approved [illegible] levels of the [illegible] lying between the Jumna and the East Kali Nuddee. Say, generally, the course would be in approximation to the latter; ~~and~~ that it would pass to the North of the towns of Bela, Kooraoli, Bhongam, Bhoun, Chibramow and onwards, keeping to the South of the ruins of Kunouj; It would terminate in the low ground between the Ganges or of the [illegible] in its proximity to it.

It

I should treat the Esun in the same way as I do the East Kali Nuddee as described in Section II, and as figured in Diagram LXVII. Feeders from the main ~~line of~~ Rajbuha would be carried boldly across the valley under precisely the same rules as those laid down for the irrigation above the Canal. Regulators restricting the quantity of Aqueducts to those where the line of Canal and the valley of the river are in the closest contiguity, and retaining the Rajbuhas at the intermediate points as feeders for the consumption lines. –

The Rajbuha from the Otha bridge, or that which is situated at the 130th mile, would probably be thrown in connection with the main Rajbuha, in that running between the East Kali Nuddee and the Esun. The [illegible] would in all probability cross the Esun by aqueduct, and not as the last of a series in which the East Kali Nuddee Rajbuha is the prominent feature.

Below the Otha bridge the Rajbuha heads would provide irrigation for the tract between the Noon and the Esun, those situated at the Munnowa and Kishnee bridges acting as the heads of supply for a main channel that would run through the low ground constituting the head of the noon and in which that river takes its rise. These

figure

lying below Kukwan, acting on the usual plan as feeders, & crossing the [illegible] by Aqueduct.

A general Sketch of the Irrigation on this part of the Cawnpoor Terminal line is shewn in the following Diagram

Diag. LXVIII

On the right of the Cawnpoor Terminal ~~Line~~, the Irrigation and the detail of the Rajbuhas are ~~to~~ for the first 65 miles somewhat more complicated. They are intimately connected by ~~the~~ ^the afflux of [illegible]^ ~~Line~~ which is as I have [illegible] [illegible] in close connection with the Rajbuhas [illegible]. To which the first 65 miles [illegible] and [illegible] the direction.

The capacity of the Etawah Terminal Line has been designed with reference to the irrigation [illegible] to the [illegible] of the Doab, to which immediately after its departure from the head at Nanoon it will be expected to throw its large supplies. [illegible] [illegible] part of the land lying between the Cawnpoor and Etawah Terminals ~~line~~ from their separation to a point 65 miles above will be irrigated entirely from the

[illegible]. The width of country
that separates these two rivers does
not exceed in average 6½ miles,
and it contains on its whole length
the Tonse River. This River will
have to be crossed on the same
plan as proposed for the East
Kali Nuddee and the Ram
Gunga should the last Assistant Engineer's
[illegible] project be adopted [illegible]
[illegible] the Canal [illegible] ~~[illegible]~~
instead of being dropped into
the [illegible], this main
line would continue on the
ridge of the country, would
sweep through the valley of
[illegible] by [illegible]
and [illegible] would
[illegible] two miles on their
approach to the Canal [illegible]
[illegible] and would ultimately
[illegible] towards [illegible] the main
line [illegible] towards the
East [illegible] of the Futtehpoor
~~[illegible]~~ Purgunna

It will be understood how-
ever, that on the first 65 miles
of the Futtehpoor Terminal ~~line~~
[illegible] supply irrigation [illegible]
[illegible] lying between the
two [illegible] and that
the [illegible] ~~[illegible]~~ heads on ~~[illegible]~~ its right bank
[illegible] as [illegible] to the great
[illegible] of [illegible] [illegible]
[illegible] to the right of the
[illegible].

[illegible] of the 65th
mile the Futtehpoor Terminal
~~[illegible]~~ continues its course in
[illegible] approximation to the
[illegible] boundary [illegible] in con-
tact with it at the 6[illegible] mile
[illegible]

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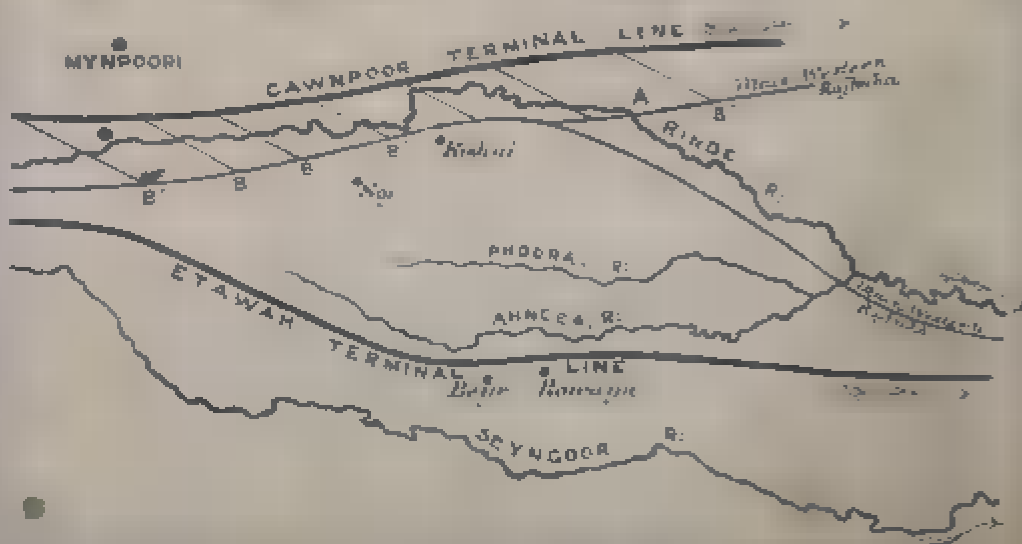
at a point opposite [illegible] of [illegible], and continues near as far as the 100th mile in such close contiguity that the rajbuhas on the right bank naturally cross the Rinde [illegible] as feeders to the great [illegible] of Raj-[illegible] which at [illegible] have been described as [illegible] through the country [illegible] Rivers.

From the starting point at [illegible], [illegible], as far down its course as the 100th mile, the Rajbuha heads on the right of the Cawnpore Terminal line will [illegible] as feeders to the main Rajbuha which runs on the opposite side of the Rinde; the detail of aqueducts [illegible] being [illegible] on the principles before suggested.

It is desirable for the purpose of retaining the command of water that the [illegible] of this [illegible] Rajbuha [illegible] at this point, [illegible] it forward and take it across the Rinde by an aqueduct as shown in the following diagram at A. A channel of equal capacity [illegible] continued onwards on the right bank and in parallelism to the Rinde, [illegible] the

Diag: LXIX



Town of Agua on the right, the [illegible] descend upon crossing the Pavon and [illegible] immediately above their junction with the [illegible]. This Pavon is the name [illegible] of the [illegible] navigation [illegible] of the [illegible] [illegible] Agua [illegible]

From the Agua [illegible] A the [illegible] ~~[illegible]~~ [illegible] would [illegible] round the heads of the Pavon and keeping on the right of that stream it would pass the Town of [illegible] 3 [illegible] having [illegible] on its right, it would cross the Pavon near [illegible] and would [illegible] with the Caboro [illegible] a [illegible] which [illegible] through the [illegible] [illegible] [illegible] campoon [illegible] ~~[illegible]~~

~~[illegible]~~

The direction [illegible] would [illegible] the [illegible] [illegible] requires to be [illegible] [illegible] [illegible] the Pavon [illegible] the [illegible] of the [illegible] [illegible] direction of the [illegible]. The country, however, is much [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible]. ~~[illegible]~~

~~[illegible]~~

[illegible] 2 [illegible] [illegible], [illegible] the vicinity [illegible] village of [illegible], [illegible]

very

very far from it. The [illegible] is
a [illegible] built on a [illegible] that
[illegible] [illegible] [illegible] and it
would be [illegible] [illegible]
a [illegible] [illegible] notwithstanding
that the [illegible] is unfavorable
[illegible] in designing the building to make it [illegible]
[illegible] [illegible] as possible.
[illegible] [illegible] (as well, I may
say, as for the same purpose in
all cases connected with these
rivers) I would use a [illegible]
[illegible] [illegible] on masonry
piers in preference to [illegible]
[illegible] [illegible] piers, occupy so
much space and offer so much
obstruction to the waterway.
The [illegible] [illegible] from
[illegible] [illegible] 20 [illegible]
[illegible] [illegible] supplied
by a State of [illegible], would
[illegible] [illegible] [illegible] des-
[illegible] the [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible], and the
[illegible] from [illegible] [illegible]
[illegible] [illegible] would [illegible]
[illegible] to [illegible]
The [illegible] of the [illegible] has
[illegible] [illegible] [illegible]
[illegible] end [illegible]
[illegible] [illegible] [illegible]
[illegible] a bridge [illegible]
[illegible]
[illegible] [illegible]. The [illegible]
at the supply [illegible]
[illegible]
[illegible] [illegible] between
[illegible] [illegible] the [illegible]
[illegible] [illegible]. The [illegible]
way [illegible] with [illegible]
a [illegible] with the [illegible] of the
[illegible] [illegible]
the

the works at this point ~~are~~ is planned with a view to main- tain[illegible] a constant supply of navigation to the head of the Cawnpore Locks, and at the same time to afford provision for all the spare water to pass off to the irrigation of the lands in the [illegible] [illegible] tracts [illegible] closing of the [illegible] Shutter in cases of drought, and in emergencies when water is not required at the works in Cawnpore, admit of the whole of the tail water being passed off for irri- gation on the Cawnpore Rajbuha. [illegible] after leaving the ~~[illegible]~~ ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] works [illegible] [illegible] [illegible] the stream [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] between the Pandoo and the Ganges, [illegible] [illegible] [illegible] [illegible] be joined [illegible] the [illegible] [illegible] [illegible] [illegible] Rajbuha [illegible] [illegible] [illegible] above des- [illegible] [illegible] and the tail water would ultimately be conducted into the [illegible], on the boundary of the Cawnpore [illegible] [illegible] [illegible].

[illegible] [illegible] observe that with [illegible] to the [illegible] [illegible] laid down [illegible] the provision [illegible] [illegible] in the vicinity of [illegible], the [illegible] [illegible] [illegible] the [illegible] of the Cawnpore Terminal ~~[illegible]~~ End ~~[illegible]~~ at the Mussawanpore Bridge, and a [illegible] situated 3 miles from the [illegible] of the Cawnpore [illegible] at the village of [illegible].

From the above description it will be [illegible] that the main Rajbuhas on the Right and Left which leave the Canal at

the

the head of the Assofnuggur falls, continue in uninterrupted lines the whole way down the Country maintaining their course parallel to the Main Canals or Reservoirs of supply. On the left; to the separation of the main trunk at Nanoon, at which point the line takes a departure to the left, keeping to the vicinity of the East Kalee Nuddee; and terminating in the Ravines and low land connected with the Hoogis and Besun; On the Right, maintaining an equally parallel course and a much greater extent even to the neighbourhood of Cawnpoor at which point it forms a junction with the Dubowlee Rajbuha, and passes off in connection with that line into the Pandoo.

The detail of Rajbuha heads, their position relatively to Bridges, their dimensions & and the general arrangements connection with discharge, are on the Etawah precisely the same as on the Cawnpoor Terminal line.

I have in the former chapter, as well as in that under the head of the Futtehgurh and Koel Branches drawn attention to some of the leading points connected with the distribution of the water from the Etawah Terminal ~~line~~ and in the detail of the works I have in a general way pointed out the method that would be adopted for

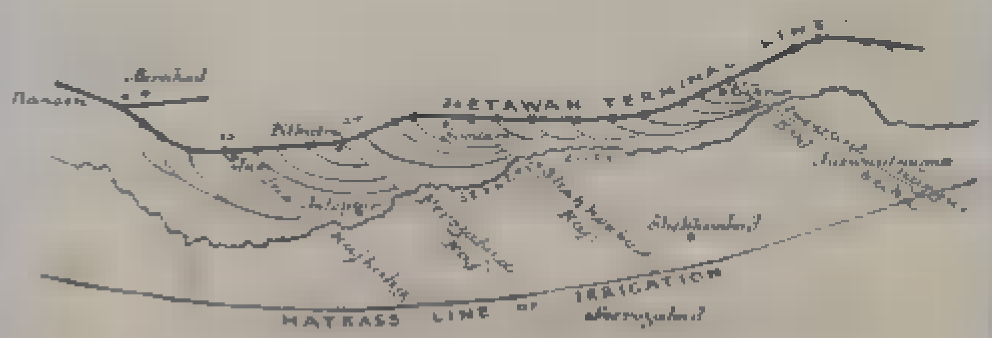
maintaining a sufficient supply to lands lying at a distance from the main canal it will be sufficient therefore in this place, whilst recapitulating the different details, to bring the whole under review as one comprehensive ~~plan~~ scheme of irrigation.

From what was said ~~in~~ before ~~the last chapter~~ it will be understood that on the leading 65 miles of the course of the Etawah Terminal ~~line~~, the supply to Irrigation will be almost entirely ~~taken away~~ drawn by the Rajbuha heads off its right bank; this supply which is intended to be free and continuous is in fact the source upon which the Etawah line of Irrigation will depend for its existence. On the form of lines above described, the Sengoor will be crossed by Aqueducts, and these Aqueduct lines (which I propose to make 11 feet in width) will be kept in supply by the intermediate ~~lines of~~ Rajbuhas which will meet the Aqueduct line on the Canal side of the Sengoor valley. I have supposed that four aqueducts with a waterway of 40 feet in width in the aggregate would be sufficient for the Etawah irrigation on the first 65 miles of the course of the Etawah Terminal ~~line~~ — the position of the four Aqueducts with their feeders may be shown in a diagram — the four main lines being designated by the leading

[illegible]

towns & places upon which or from which they are directed

Diag: LXX.



The more numerical extent to which these aqueduct lines are carried is, however, a question of economy, either in the expenditure of money on the works themselves, or on that of water; the detail, therefore, must necessarily be left to the future. — The capacity of the Etawah Terminal ~~Line~~ however has been determined on the large and efficient supply which must necessarily be extracted for the purpose of the [illegible] Irrigation. And I consider that as far as the 100th mile of the course of the Terminal Line it is available in the fullest possible way for affording supplies to as many aqueduct lines as can conveniently and economically be pushed over the Sengur valley. —

The question ~~[illegible]~~ [illegible] Rajbuha which crosses the Etawah Terminal ~~Line~~ and proceeds forwards on the right bank of the Sengur

is on the west be limits its
course supplied almost entire-
ly from the [illegible] Terminal ~~[illegible]~~
It will be provided with [illegible] of
the Planes, [illegible] ones [illegible]
for [illegible] ways
in the [illegible] that [illegible] the
supplied [illegible] [illegible] this
course is [illegible]
of [illegible]
of [illegible]
[illegible] the [illegible] Rajbaha
[illegible]
be understood as [illegible] the [illegible]
[illegible] in [illegible] of pro-
ceeding parallel with the Etawah
Terminal ~~[illegible]~~ retains its founda-
tion with the [illegible]
the [illegible] of the Phoo
and [illegible] has been
[illegible] this [illegible] on
[illegible] Rajbaha [illegible]
the [illegible]
the town of Ayrwia [illegible]
[illegible] the [illegible] of a [illegible]
[illegible] its [illegible]
to the [illegible] regarding its
position relative to the Etawah Terminal
~~[illegible]~~ by [illegible] the [illegible] two
[illegible] at a point [illegible] their
junction.

To the above ~~[illegible]~~ supplied
by Etawah Branch [illegible] the
[illegible] to the [illegible]
[illegible] a [illegible] supply from
each of the intermediate Rajbaha
heads. A further supply will be
delivered by aqueduct from the
heads between the Sengur and
[illegible] across the
[illegible], to the strip of land
lying between that River and
the [illegible]. The main Rajbaha
~~[illegible]~~

~~this~~ will be kept well supplied with water from the Cawnpore Terminal line just described and in a more paying way by aqueducts carried across the Nuddee in the neighbourhood of [illegible], or [illegible] &c.

Confining my description to the Irrigation system on the left of the Canal Terminal ~~line~~ the [illegible] ~~[illegible]~~ Rajbuha after leaving the [illegible], proceeds towards [illegible] ~~the Terminal~~ that line at the Nuddee, receiving in its course a supply from the different Rajbuha heads, until it has passed the [illegible] Rajbuha; at this point instead of proceeding onwards parallel to the Canal, it follows the course of the Nuddee in the same way that it does on the former occasion, keeping on the [illegible] of the tract of land lying between the [illegible] and the Nuddee. From the different Rajbuha heads situated above the [illegible] [illegible] this main line of Rajbuha and its different branches will receive their supplies ~~its supplies~~. This main line ~~It~~ will provide irrigation for all the Eastern portion of the Futtehpore Pergunnah, and it will be aided in this by cuts for ~~[illegible] of~~ Irrigation taken from the different Rajbuha heads lying between Akbarpore and the Canal Terminus.

By the above arrangement the [illegible] Pergunnah [illegible] Rajbuha or rather that branch from it which commences from the town of

of Agwa, will terminate after having run continuously for a distance of 331 miles in the ravines [illegible] the [illegible] of the Jumna in the [illegible] of [illegible].

Looking to the right of the Etawah Terminal Line, it has been shown that the first 65 miles of its irrigation will be almost entirely devoted to the Kallass line of Irrigation, and that even as far as the 100th mile, or up to the Mulkosi Escape, the above line will be supplied by Regulation from the Terminal by Aqueduct across the Sengur. The system however which leads to the necessity of such a large quantity of water being taken in the Irrigation of the country lying on the right bank of the Sengur makes provision also for the lands which lie intermediate, all of which have the means of irrigation provided by the main Aqueduct line as well as by its feeders. To the extent therefore of the supply of water, the whole tract of country lying on the right of the Etawah Terminal from the 1st to the 100th mile of its course will be irrigated.

In advance of the 100th mile, keeping in view the advantages of securing a thorough circulation of fluid, and the consequent necessity for maintaining a main Rajbuha, or as we may term it a Catch channel for the spare water of the different feeders, I would adopt the last.

in the Croya Aqueduct line, at the source to a connection [illegible] of the pipes which would extend from that point to the [illegible] ~~at the [illegible]~~ at the same line.

I imagine that this last line will leave the [illegible] line at the [illegible], and that it will join the [illegible] line [illegible] near the town of Croya, [illegible] by [illegible] the Aqueduct [illegible] it [illegible] 2 [illegible] the [illegible]. The total [illegible] of this as it may be called, the line running along the Croya Aqueduct will be about [illegible] miles; in its course it [illegible] supplies [illegible] that the [illegible] [illegible] it [illegible] the Aqueduct [illegible] the [illegible] at the town [illegible] the [illegible] Aqueduct [illegible] should be [illegible] to [illegible] of the [illegible], and I would [illegible] the [illegible] passages over the [illegible] [illegible] to [illegible] the [illegible].

[illegible] the Croya [illegible] a [illegible] cut would be [illegible] at a point about 3 miles from its [illegible] [illegible]; it would run parallel to the [illegible] at a [illegible] distance, [illegible] in its passage a supply [illegible] of the [illegible] [illegible]

and Miller. This main ~~[illegible]~~ cut would probably reach the Terminal ~~[illegible]~~ at a point below the Town of Washington, or it might terminate in the same way as the main aqueduct on the left, by falling into the ravine of the [illegible] river in the neighborhood of the village of Bladensburg, or in [illegible] still further on, near the town of [illegible].

The laying out of highways on the plan that I have represented necessitates the crossing by aqueduct of every tributary, to which the ~~[illegible]~~ highways run at right angles, and the crossing by aqueduct is by no means so [illegible] expensive or a very difficult. Whatever, then, the advantages [illegible] may be [illegible] in [illegible] sufficiently [illegible] in a position capable of [illegible] into [illegible] that I do not object [illegible] to a moderate [illegible] of building of aqueducts, if the advantages above described are very [illegible].

The [illegible] Irrigation from the [illegible] and [illegible] Branches will be conducted on the same principles as those above described, [illegible] by parallel [illegible] of main highways [illegible] from the different heads, these branches will cease in the first case on the right bank of the river, and before the branch reaches that river; and in the latter at the junction of the two branches. In [illegible] of this

junction

junction the Etawah line will deliver its water for irrigation immediately from the main Channel, which is supplied, as above discussed, by feeders from the Etawah Terminal ~~Line~~. The description, however, will be more distinct by the following Diag: which represents an outline of the system of proposed Irrigation from the [illegible] Chay-[illegible] at the 6th mile to the [illegible] at Ubbeeshur and Mowza [illegible].

Diag: LXXI.

The Futtehpoor Branch which leaves the main Canal at the 61st mile distance, and runs on the watershed or summit level of the belt of the Country bounded by the last named river and the Ganges, will form an equally comprehensive system of irrigating courses on the same plan as was here described before. This Branch is proposed to terminate at the 101st mile of its course as an irrigating medium; the channel in prolongation being specifically designed, for boats, rafts &c., and for the pur-

pose of connecting Puttiguil with the main ~~Line~~ Trunk by water carriage.—

From the departure of this Branch, which is from the main Canal at Nadi, a mile or two down from the head of the Falls which are ~~[illegible]~~ situated below it, main lines of Drainage would be carried on the right and left parallel to the course of the Branch running at [illegible] from [illegible] near [illegible] in succession. The drainage lines would terminate in the navigable channel, at some convenient point below the 100th mile. The system of ~~[illegible]~~ Drainage [illegible] with a complete [illegible] of the Canal would, it may [illegible] placed in the Puttiguil Branch as it has been proposed to be done on the whole of the Canal [illegible]

[illegible] to which this system of drainage has been [illegible], it has not been [illegible] any [illegible] upon [illegible] deposit [illegible], the presumption that [illegible] attempt at fixing the position [illegible] distribution of water. These must necessarily depend [illegible] upon the result of [illegible] acquired [illegible], and on the wants of the country, [illegible] qualifications of land [illegible] regulation [illegible] & [illegible] into the details is the recognised fact

act, that a plan once laid down offers a base upon which something may be constructed. If the plan shows nothing but the ignorance of the designer, it has the merit of pointing out the evils to be guarded against; if generally or only moderately applicable to the purpose, it relieves others from preliminary and rudimentary trouble, and enables the mind to be employed on improving that of which the original is the [illegible] work.—

In the present case, the interference of Rivers, and the peculiarity in the conditions of the country through which the Doab Canals take their course, render the distribution of the Rajbuhas ~~[illegible]~~, a constant and complicated question; it is one that has given me much thought, and the conclusions at which I have arrived, are the results of mature and deliberate consideration.— The general principles are derived from those which originated on the Western Jumna Canal, and which have been attended with the greatest success not only in economizing the supply, and in facilitating the distribution of water to the Cultivators; but in protecting the interests of both the Government and those who are dependant upon the Canals for irrigation. The details will offer illustrations of [illegible] operations, and a groundwork for bringing to completion that which I have only written the

but you began; and I shall have explained myself very imperfectly if these details are viewed in any other light than the narrowest possible outlines, on which our general and uniform [illegible] lines of continuous [illegible] throughout a free and wholly unfettered circulation of [illegible] has been contemplated.

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PART. III.

[illegible]

CHAPTER I

[illegible]

[illegible]

I. [illegible]

II. [illegible]

III. [illegible]

IV. [illegible]

V. [illegible]

[illegible]

[illegible] to the [illegible] ~~[illegible]~~ drainage caused by the intermittency of the [illegible] of [illegible], the [illegible] to be derived from them, [illegible] local, and [illegible] to the ~~[illegible]~~ other [illegible] in the [illegible], [illegible] on the [illegible] [illegible] [illegible], [illegible] the [illegible] of the [illegible] buildings.

I. [illegible] [illegible] [illegible] at a [illegible] [illegible].

[illegible] [illegible] [illegible], although they [illegible] be classed [illegible] the [illegible] [illegible] [illegible], the supply [illegible] not [illegible] under the [illegible] [illegible] [illegible] and drainage [illegible] and [illegible] [illegible] [illegible] [illegible], whilst the [illegible] [illegible] situated at [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

II. [illegible] the means ~~or~~ of regulating [illegible] supply.

[illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] without any [illegible] [illegible] [illegible] [illegible] [illegible] by ~~the~~ [illegible] ~~of~~ [illegible] [illegible] [illegible] the [illegible] supply [illegible] [illegible] at that point [illegible] [illegible] from the [illegible] [illegible] [illegible] [illegible] [illegible] ~~of~~ [illegible] the [illegible] without ~~[illegible]~~ affecting in any way ~~[illegible]~~ the [illegible] [illegible] [illegible] [illegible]

the t[illegible] it may be prop[illegible] applied to the water, on its approach to the works through the Upper end of the Rudwa Branch of the Canal, it ~~is [illegible]~~ only a [illegible] of the Canal works ~~[illegible] the Town~~ immediately connected with [illegible]. In the same category may be included the Inlet for the Rajbaha [illegible] which enters the branch on the upstream side of the Regulator; this consists of [illegible] arches with a waterway of 20 feet width ~~[illegible]~~ and a fall in the shape of an Ogee ~~which~~ [illegible] of a few feet; other buildings attached to the upper works.

At the crossing, the [illegible] [illegible] [illegible] feet with [illegible] at that place; it drains the [illegible] water into the Canal [illegible] [illegible] which are shown directly opposite to it, the object of the building which forms the [illegible] the [illegible] of the Canal supply within a limited space [illegible] assigned ~~[illegible]~~ ~~it~~ [illegible] the Inlet [illegible] during the floods when [illegible] are not [illegible] ~~it enables us to~~ had ~~the attainment of~~ this object been unnecessary, and had the inundation which would otherwise have been consequent on ~~[illegible]~~ ~~upon~~ the [illegible] of water into the Canal, been of no ~~im~~ importance ~~[illegible]~~, the design of the works here would have been [illegible] that made at Ringopur [illegible] so far that the Railway [illegible]

[illegible] on either side, while [illegible] have been left [illegible] and unim-proved by Masonry works every condition. The detail of this last class will more properly belong to the description of the [illegible] at Dummoodum [illegible] the [illegible] River. The weirs, or that which are attached to the tanks at Tinjapoor and Dummoo are altogether peculiar to their ~~particular~~ position and use, and on this account I have in-cluded them in the present letter.

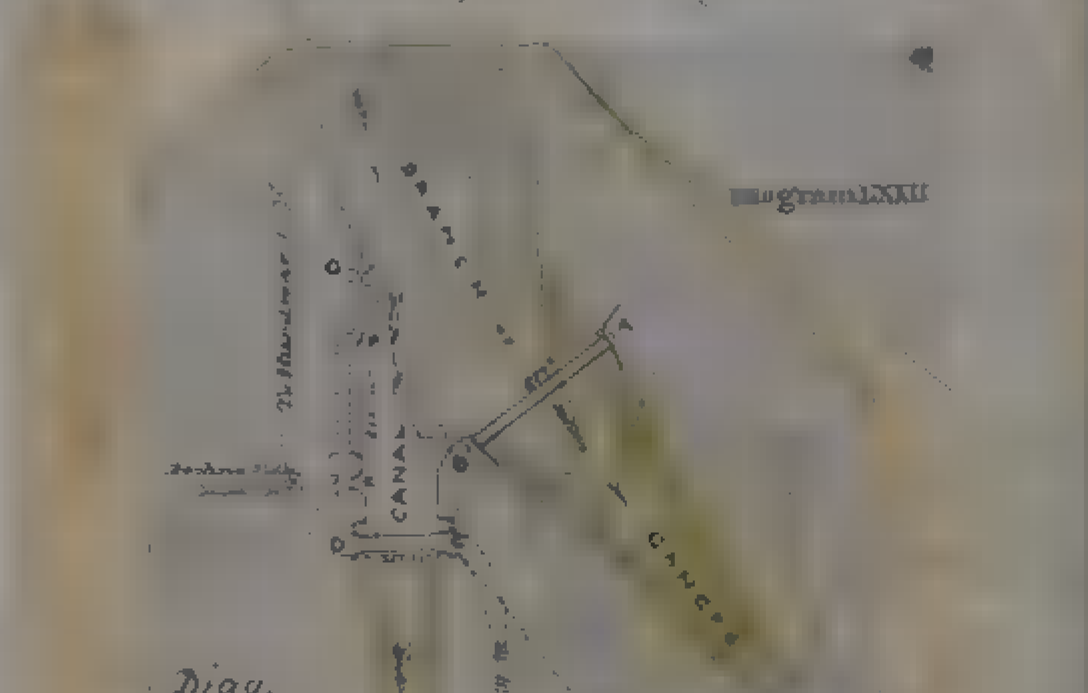
From the above it will be understood that the two [illegible] here under the head of this letter, are each two [illegible] [illegible] situated in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the other [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] capacity of [illegible] [illegible] it [illegible] passing [illegible] [illegible] [illegible] they pass off floods during the rainy period and [illegible] water at other times; at other [illegible] [illegible] when [illegible] [illegible] they act as [illegible] to the [illegible] supply, they may be described as Masonry [illegible] thrown across the bed of the river, with [illegible] [illegible], and with [illegible] [illegible] [illegible] the [illegible] fitted with [illegible] taking the [illegible] [illegible] description [illegible]

built out into the stream, and by [illegible] order of [illegible] the [illegible] that comes under review is the

[illegible] Dam and [illegible]

The plan of the works, which are connected with the departure of the Canal supply from the Ganges River and its Branch at Myapoor, is shewn in all its detail in Plate XXIV of the Atlas.

The works consist of a Dam thrown across the Branch at a point 3800 feet below the [illegible] of [illegible] and at the site of what was [illegible] called the [illegible] Ghat. This Dam is connected on its right flank [illegible] Revetment wall, with a bridge of 10 waterways built across the mouth of the canal, on the right and upstream side, a line of [illegible] [illegible] [illegible] the bank of the River, abutting upon the right wing of the Bridge. The position of the works may be understood by the following Diagram.



The whole of the portion, [illegible] that point in the [illegible] and the [illegible] [illegible] is equal to [illegible] 19th April, [illegible] [illegible] [illegible] materials [illegible] placed [illegible] the [illegible] in the diagram.

The foundation [illegible] at [illegible] Dam, Bund [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Richard [illegible] of the [illegible], [illegible] the work [illegible] [illegible] and a part of the [illegible] [illegible] completed.

[illegible] was succeeded by [illegible], who made [illegible] ~~[illegible]~~ to his successor Lieut. Alfred G. Goodwyn in 18[illegible], under [illegible] [illegible] [illegible] the Superstructure of the 19 arches as well as that [illegible] [illegible] [illegible], and the whole of the work [illegible] completed [illegible] [illegible] [illegible] [illegible] access to the Ghats, and [illegible] outline of the Cornices [illegible] courses is due — The [illegible] nulla, a mountain [illegible] of moderate dimensions is admitted into the works thro' an archway of 20 feet in width [illegible] is pierced through the [illegible] Revetment at the point E in the diagram; the water at this Nulla [illegible] reaching the works has a [illegible] of 10 [illegible] [illegible] [illegible] [illegible]

[illegible]

[illegible] into a [illegible] [illegible], offering a [illegible] [illegible] [illegible] [illegible]. 268½ feet above the [illegible], the Boorea Nuddee is crossed by a Bridge [illegible] with the [illegible] [illegible] the Canal [illegible] as the [illegible] [illegible] [illegible] between the [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] to the Booree Nuddee, were completed by [illegible] [illegible], and before the [illegible] [illegible] [illegible] assuming charge of the [illegible] duties. [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] of [illegible] [illegible] constitutes a portion of the right [illegible] [illegible] [illegible] [illegible] sufficient [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ the Canal [illegible] [illegible] [illegible] [illegible] [illegible] Government [illegible] at intervals [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at the [illegible]; [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the Booree Nuddee.

The ~~[illegible]~~ design of [illegible] [illegible] [illegible] [illegible] buildings of the same description which existed previously to the [illegible] of the works. ~~[illegible] [illegible] [illegible] [illegible] [illegible]~~ A [illegible] [illegible] [illegible] [illegible] [illegible] of great antiquity [illegible], ~~[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] parallel to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible], [illegible] [illegible]~~

from Hurdwar to Kunkhul along the edge of the high bank & parallel to the branch of the Ganges. Its [illegible] [illegible] continuous [illegible] [illegible] at those points where the several Torrents broke through [illegible]. It [illegible] the line of [illegible] communication between the

~~and there by noble specimens~~ ~~of the Banyan (Ficus religiosa)~~ ~~Peepul (Ficus [illegible])~~ [illegible] [illegible] by the ~~[illegible]~~; under the shade of these Trees, and at [illegible] distances apart from [illegible], [illegible] platforms, [illegible] [illegible] Fakirs, [illegible] sat and [illegible] the adulations of [illegible] [illegible] It [illegible] [illegible] at [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] situated in the middle of [illegible] [illegible] [illegible] [illegible] [illegible] each [illegible] possessed [illegible] [illegible] ~~[illegible]~~ It would [illegible] their intermediate [illegible] as [illegible] [illegible] [illegible] each successive year [illegible] the [illegible] pilgrims, the same Fakir sitting in the same platform, in all probability with the same [illegible] hair, and with the same [illegible] unwashed, and [illegible] countenance.

[illegible] a necessary consequence of the excavations at the Canal head, and their [relation] to the [illegible] road, a number of [illegible] which has been [illegible] down; [illegible] this [illegible] was taken of the opportunity to place [illegible] features [illegible] [illegible] [illegible] [illegible] [illegible]

two Trees for the Pilgrims frequenting the Hindoo fairs was richly wooded; & marked here & there by noble specimens of the Burr (Ficus Religiosa) Peepul (Ficus Indica) & the Trees loved by the Hindoo.

as now situated, this position would [illegible] removed from that ~~to~~ occupied by them ~~[illegible]~~ originally ~~[illegible]~~, and a large Bar ~~[illegible]~~ tree which in all probability was the centre of attention to the neighbourhood, stands with its [illegible] around the old Mosque, necessarily removed ~~[illegible]~~ now performs its former office to the new buildings, standing on an esplanade [illegible] for the reception, and protected on the River side by a retaining wall of masonry as shown on the diagram at the letter G. —

I have already stated that the Channel [illegible] has been excavated from the Ganges to the projected Dam and regulator, is 300 feet in breadth, and a depth of 8.50 feet per mile, [illegible] this depth also the tail excavation [illegible] the Dam towards the [illegible] of [illegible] has been excavated, the extent to which this has been carried, is shown in a profile shown in Plate No XIII of the Atlas. The additional improvements that are proposed in the neighbourhood of Hurdwar and the bathing ghauts, with different suggestions for facilitating [illegible] and egress to the water [illegible] have been described in paragraph 9 of the 3rd part, I shall proceed with the details of the Dam works, the outline of which together with that of the Channel previous to its having been touched by the excavation, is shown in the foregoing Diagram. —

The [illegible] part of the Dam

it

it will be observed, also, upon our Plans, in which nearly one half of the full width was excavated, the ground at the point of contact, although terminating at a short distance from the rock, is composed of compact earth and shingle, and affords a sound and sufficient resting place for the Dam walls. The [illegible] falls within the [illegible] of the [illegible] as it existed at the period when the walls were [illegible], and is [illegible] covered by shingle [illegible] excavated from that portion of the mouth which is west of the Regulator. The outline of the earthwork [illegible] as they now [illegible] by the yellow [illegible]. The red shade representing that of the dam, bridge and [illegible].

The floorings of the Dam and ~~[illegible]~~ of the Regulating Bridge are laid on one level, and the front line of the latter is the Zero upon which the whole of the Canal excavations are referable ~~[illegible]~~. The Zero level was used by me on my original survey, it was in at the bed of the stream at that period as nearly as the adjustment had [illegible] of the [illegible] between the head of the 1st set of Falls at Bahadarabad and the foot of the [illegible] that you adjusted to, would [illegible] [illegible] —

The Depth of the Bench [illegible]

[illegible]
[illegible] the [illegible] depth
[illegible] is, 62 ft [illegible]
[illegible] 850 ft [illegible]
[illegible] of [illegible]
[illegible]
[illegible] a [illegible]
[illegible] all the [illegible]
[illegible]
the supply of water [illegible]
[illegible]
[illegible]
[illegible] upon the [illegible]
the [illegible]
[illegible]
[illegible] [illegible] deposits
[illegible] caused by the
[illegible] brought down
[illegible] in the [illegible]
[illegible] deposits also
[illegible] the 100-[illegible]
[illegible] that [illegible]
[illegible] and [illegible]
[illegible] well
[illegible]
[illegible] perpendicular [illegible]
[illegible]

The [illegible]
67 feet between the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] as low as
[illegible], the [illegible] about
[illegible] 3 [illegible]
[illegible]
the [illegible]
[illegible]

[illegible] the [illegible]
[illegible] [illegible]
[illegible]
[illegible]
[illegible] during the [illegible]
[illegible] com-
munications [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] are 30 x 1[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] BC [illegible]
[illegible]
placed in the [illegible]
supposed to [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
the [illegible]
means [illegible]
[illegible]

of the measurement No. 11 are
[illegible] to be laid upon which carries
the water upon the natural
bed of the river consisting of
large boulders & rocks.
[illegible] which are
[illegible] the water [illegible]
[illegible] with the foundation timber
[illegible] [illegible]
[illegible] [illegible] and with
[illegible] a batter [illegible]
[illegible] [illegible]
[illegible] [illegible] effect [illegible]
the [illegible] [illegible] to a
[illegible] [illegible] of steps
[illegible] [illegible] the [illegible]
[illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible]
of the [illegible] [illegible] corresponding
[illegible] with that [illegible]
of the [illegible] with which it
[illegible] [illegible].

[illegible] foundation timbers
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] and [illegible] filled
[illegible] [illegible] apparatus
[illegible] [illegible] [illegible]
[illegible] [illegible] plate [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] walls
[illegible] [illegible] [illegible], and
the [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible]

[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] the up and
down stream [illegible] of the bridge.
the

the latter are essential when accidents occur to the gratings or to the apparatus for moving them; and they provide an alternative which without them does not exist. In the present case the deviation in the original design in the superstructure [illegible] has deprived us of these conveniences, and it is not possible without a total reconstruction [illegible] to restore [illegible]. [illegible] the apparatus is different to that which has been adopted in the [illegible] canals; it affords much greater facilities for working, and [illegible] the opening and shutting of the rays in a much shorter period of time: both of these objects are of great consideration when we are opposed to the immediate action of the ranges, the extreme high water [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] the [illegible] regulation [illegible] [illegible] [illegible] a [illegible] [illegible] will [illegible] [illegible] [illegible] upon the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] approach [illegible] [illegible] [illegible] always [illegible] and [illegible] [illegible] [illegible] [illegible] must [illegible] [illegible] that [illegible] the [illegible] [illegible] we [illegible] [illegible]

[illegible]

Diag: LXXIII.

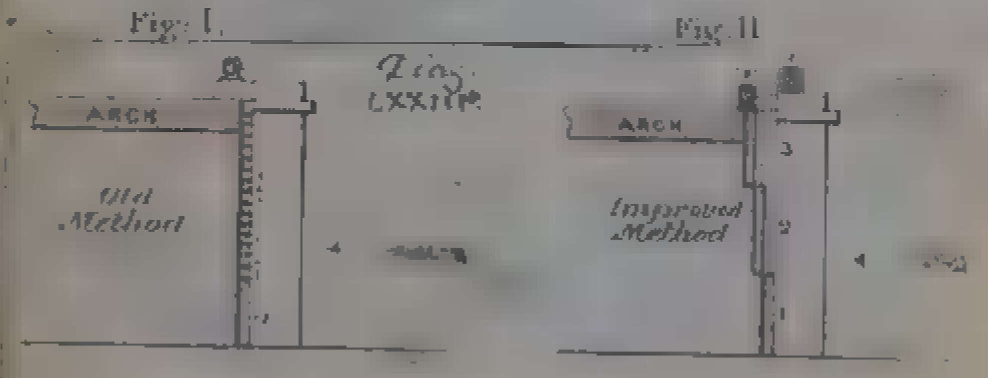


Fig: I.
Fig: II
Diag. LXXIII
ARCH
ARCH
Old Method
Improved Method
1
2
3

[illegible]

means [illegible] placed to [illegible] [illegible], the [illegible] difficulties [illegible] [illegible] by actual evidence [illegible] [illegible] of the [illegible].

Fig. II. [illegible] [illegible] The [illegible] marked 1 [illegible] on the Bell crank "1". That marked 2 from the Bell crank "2"; that marked No 3 [illegible] which is worked and [illegible] the [illegible] the 3 [illegible] depth [illegible] each has its own [illegible] and the [illegible] if necessary be worked simultaneously. The great advantage of this method [illegible] by supposing that a supply of water [illegible] [illegible] depth [illegible] the [illegible] of the [illegible] may [illegible] and [illegible] the [illegible] of the levers [illegible] [illegible].

Suppose [illegible]

the [illegible] supply is 11 feet
[illegible] depth to pass [illegible] through the
[illegible] and 8 at [illegible] of
[illegible], it is necessary to [illegible]
the [illegible] shutters [illegible],
[illegible] 3 [illegible];
and [illegible] shutters
[illegible] separate [illegible].
[illegible] simultaneously
[illegible] almost
instantaneous [illegible]
[illegible] in the regulation. It was
[illegible] for navigation [illegible]
[illegible] one of the bays
[illegible] depth [illegible]
[illegible] boats [illegible]
[illegible] floods.
[illegible] boats [illegible]
[illegible] the [illegible]
the inconvenience [illegible]
[illegible] navigation. The [illegible]
[illegible] gates
[illegible] construction,
[illegible] the [illegible]
[illegible] the [illegible]
liable to [illegible];
[illegible] of ~~[illegible]~~ [illegible]
[illegible]
[illegible] heads [illegible]
~~[illegible]~~ [illegible]
the [illegible]
by ~~[illegible]~~ hand springs, the [illegible]
[illegible]
length of 3 [illegible] with plain
[illegible] shutters [illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible] used [illegible]
[illegible] the [illegible]
[illegible] force.
[illegible]

The above will with the addition of Plate XIV [illegible] give a tolerably [illegible] of the Dam and regulating bridge, it being understood that [illegible] the [illegible] [illegible] [illegible] [illegible] the [illegible] closed, the water is [illegible] [illegible] over the Dam, the [illegible] [illegible] [illegible] for the purpose [illegible] [illegible] regulating the supply [illegible] [illegible] the [illegible] [illegible] with [illegible] [illegible] ~~[illegible]~~ in detail.

Plate [illegible] [illegible] that [illegible] [illegible] is the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] the regulating bridge. [illegible] that [illegible] [illegible] [illegible] ~~[illegible]~~ symmetrically situated on the right, [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] similar to that [illegible] [illegible] opposite side [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] which is equal to 50 feet in width. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 256 feet in length. [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at the upstream end, [illegible]

[illegible] This
[illegible] revetment [illegible]
[illegible] was [illegible]

[illegible]

[illegible] not only [illegible] but is a positive evil [illegible]

[illegible] improve the [illegible]

[illegible] the building of the [illegible]

In beginning [illegible] the foundations [illegible]

[illegible]

[illegible] employed [illegible] following proportions

1 Part Lime (Stone)
1 — do — Soorkee

The proportions of lime and soorkee [illegible] different species of masonry are, viz

Boulder masonry	Brick masonry
1 Part Stone Lime 1 — Soorkee 1 — Sand	1 Part Stone Lime 1 Part Soorkee

[illegible] the materials expended [illegible] rates of [illegible] was [illegible]

Total cubic content of masonry	520101 cubic feet	
Materials expended		
Bricks 12"x6"x2½"	364821	
Do — 12"x6"x2"	535744	
Do — small	2700	
Boulders	335000	maunds
Stone Lime	98690	cubic feet
Soorkee	96991	do
Brick masonry	19 10 5	per 100 cubic feet
Boulder — Do	4 ˑ 5	per do
Plastering	6 5 11	per 100 sq. feet

[illegible]

[illegible] works [illegible] bridges [illegible] and to this the woodwork required, which only have been transported at a [illegible] [illegible]

[illegible] the latter [illegible]

[illegible] 100 cubic feet [illegible] 19.5.11 only.

LXXV

DHUNOWRI [redacted]

Shewing the position of the Masonry Works with reference to the Rutmoo River and the method to be adopted in directing the Stream of that River upon the main Works.

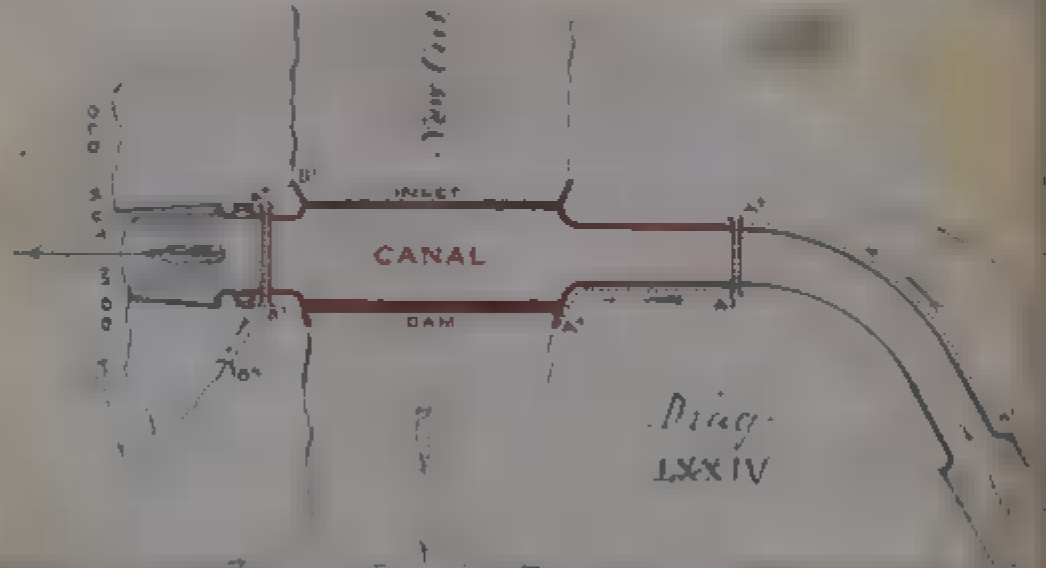
Scale 2400 Feet to an Inch

The Blue Tint shews the extent of Inundation in the Rutmoo valley, with a depth of 10 feet in Canal.
The Blue Figures the depth of water. The Red Figures the height of land above the surface level of Canal.
The Dark purple tint shews the State made Previously to the rains of 1852 so as to allow the floods of that year to act on the intended bearing.

[illegible] Works

These works [illegible] and [illegible] thrown across the [illegible] [illegible] [illegible] with the [illegible] [illegible] with a variety of [illegible] works appended to them. They are situated between the 13th and 14th [illegible] [illegible] [illegible] [illegible] [illegible] takes place in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible] details will [illegible] [illegible]

Ch 2600
18.63.



[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ lead to [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] ~~[illegible]~~ determined [illegible] [illegible] [illegible] have been described, [illegible] [illegible] [illegible] [illegible]

of the storm consequent on the absence of works for their prevention have been especially [illegible]; it was suggested that a well managed outlet with efficient drainage might relieve also the country from inundation and that it was possible [illegible] ~~[illegible]~~ [illegible] ~~[illegible]~~ [illegible] might be [illegible] for the whole of the design in such a way that all the [illegible] [illegible] be obtained. I believe ~~that~~ this has been done and that the works as constructed will relieve the country from inundation, and at the same time give a free escape to any water that may [illegible] down the River or [illegible] way by leakage [illegible] [illegible].

The canal at its intersection with the Rutmoo River, meets it on its own level, the sills of the different works therefore are on the level due to the ~~[illegible]~~ particular slope of the Canal bed calculated on the distances from the [illegible] [illegible] regulating bridge.

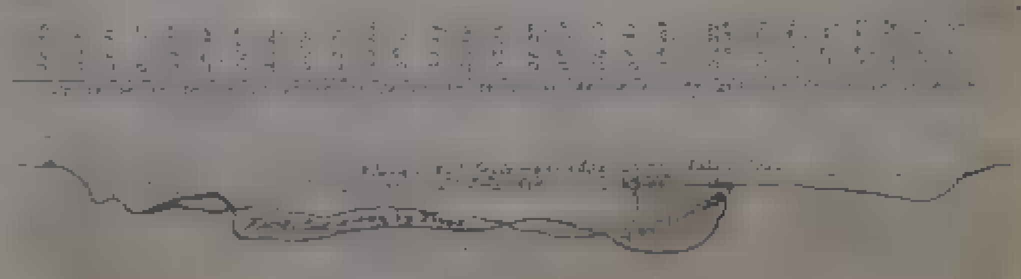
The Rutmoo [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] body of water, but [illegible] [illegible] [illegible] character, in the driest weather, and when there is no [illegible]

[illegible]

[illegible]

B 2600
B.66-

Diag. LXXVI



[illegible]
Black Line [illegible] 1850

[illegible]

as the usual [illegible]
the [illegible] [illegible] of the [illegible]
[illegible], [illegible] [illegible]
[illegible] [illegible] and [illegible]
[illegible] to the neighbour-
hood; [illegible]
[illegible] by [illegible]
[illegible].

The [illegible]
[illegible] the [illegible] that
[illegible] supposing
that [illegible] and
that [illegible]
10 feet of water was [illegible]
the Canal, without [illegible]
[illegible] the volume
[illegible]
to [illegible] sufficient that
[illegible]
[illegible] of the depth due on of water on the inundated surface & the height of dry land above its surface.
~~[illegible]~~
~~[illegible]~~

[illegible] that
the [illegible] Egypt
[illegible] natural channel
[illegible]
[illegible] at the
[illegible]
[illegible]
[illegible] with
[illegible]

[illegible]
[illegible] and [illegible]
[illegible] of the [illegible]
[illegible]
in the [illegible] a system of trans-
[illegible]
[illegible]
[illegible] Delta [illegible]
[illegible] the [illegible]
of the [illegible]
[illegible] [illegible]
[illegible]

[illegible]

main Torrent for the purpose of releasing the right side of the Valley from inundation. The Spurs which abut on the right

[illegible]

been made of extraordinary width and in a form which is shewn in the plans, the object being to cover the Bhugulwora by as great an extent of raised Embankment as was possible. The Embankments on the right or those which are more directly opposed to the Nutnoo Torrent have also had increased height and width given to them

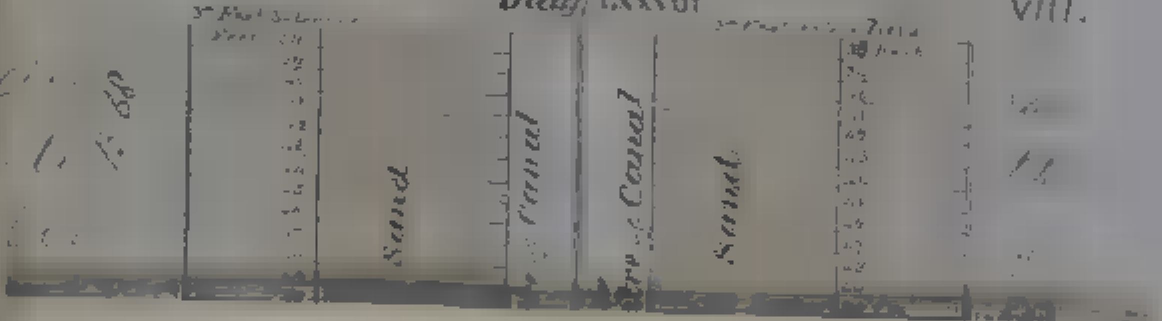
[illegible]

[illegible] as follows. –

Diag: LXXVII

[illegible] A to A″ [illegible] Diag [illegible] LXXIV [illegible] depth [illegible] with [illegible] with [illegible] Diag CLXVI [illegible] X. [illegible]

Diag: LXXVIII



[illegible] work

[illegible]

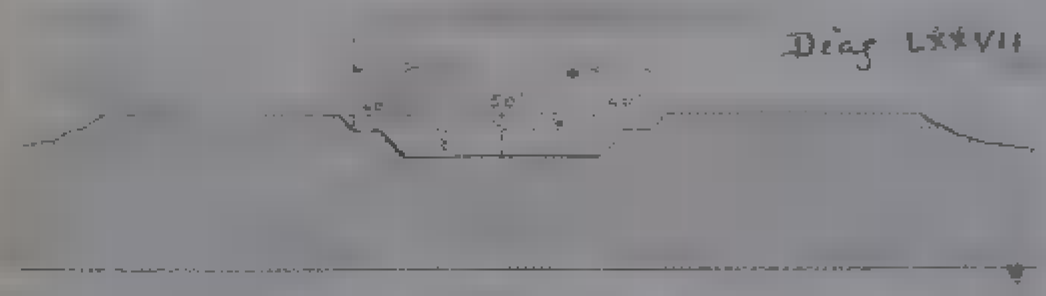
works will enable the reader to
[illegible] in the detail which
[illegible] were about to enter upon
and to appreciate the difficulties
that were overcome and the pains
[illegible] that attended the design
and progress in bringing the
~~[illegible]~~ works to completion.

The [illegible] works were
commenced in the early part of
1861 [illegible] the [illegible] account
of Mr. Thomas [illegible] [illegible] the [illegible]
tion of the [illegible] works [illegible]
[illegible] [illegible] of the
Estate on which the works are
situated) [illegible]
states [illegible]
[illegible]
of Railroads, and all [illegible]
[illegible] regarding the
[illegible] of the works, were
[illegible] in [illegible]
[illegible] detail [illegible]
[illegible]. The ~~[illegible]~~ [illegible]
of the [illegible] [illegible]
the works [illegible], but [illegible]
[illegible]
[illegible] the [illegible]
of the greatest possible advantage.
The [illegible], although [illegible]
large quantities of the [illegible]
[illegible], was [illegible]
the [illegible] [illegible]
[illegible] it was [illegible] a
[illegible] [illegible] to
maintain a lot of [illegible]
a Native brick kiln ~~[illegible]~~
as well as a series of 22 [illegible]
kilns. The Bricks for the latter
were made [illegible]
[illegible] and [illegible]
were supplied [illegible] by [illegible]

River as follows.-

Diag: LXXVII.

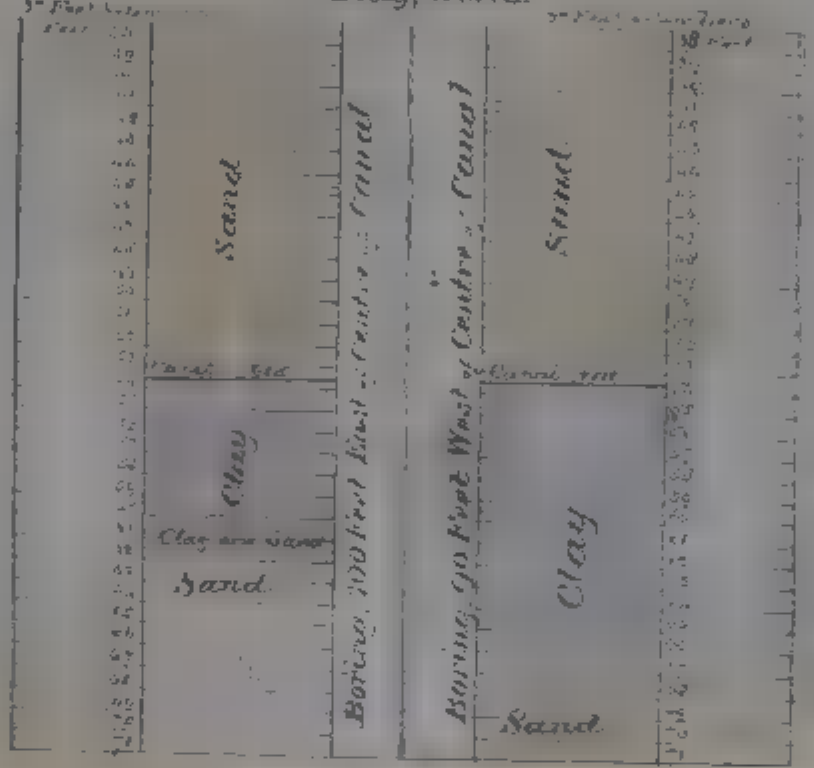
Diag LXXVII



[illegible] "A to A" [illegible] Diag. LXXIV. [illegible]

[illegible] Diag CLXVI [illegible] X. [illegible]

Diag. LXXVIII. VIII.



Note for the Printer

This diagram is [illegible] to allow for the words "Boring 100 feet [illegible]" and "Boring 90 feet [illegible]" to be set up in a line [illegible]

works will enable the reader to comprehend the details which I am now about to enter upon and to appreciate the difficulties that were overcome and the repeated disappointments that attended the [illegible] in bringing the ~~[illegible]~~ whole to completion.

The [illegible] works were commenced in the early part of 18[illegible] under the management of Thomas [illegible] [illegible] the [illegible] of the [illegible] [illegible] made [illegible] (the name of the Estate on which the works are situated) has until then been [illegible] state [illegible] [illegible] [illegible] of [illegible], and all information regarding the [illegible] of the works, was [illegible] [illegible] [illegible] [illegible] detail [illegible] [illegible] [illegible]. The ~~[illegible]~~ [illegible] of the [illegible] [illegible] to [illegible] the works [illegible], but [illegible] [illegible] [illegible] [illegible] [illegible] of the greatest possible [illegible]. The brick earth, although [illegible] in great quantities in the [illegible] situation, was [illegible] in the immediate neighbourhood where it was [illegible] a [illegible] [illegible] [illegible] to maintain a lot of Puzzewas or Native brick kilns ~~[illegible]~~ as well as a series of 22 English kilns. The Bricks for the latter were made by hand on masonry platforms and the [illegible] were supplied [illegible] by [illegible]

of Hall's brick making machine, the advantages [illegible] having [illegible] under the kind of materials. After [illegible] out the brick yards and [illegible] the position of the [illegible], the brick manufacturers were [illegible] to the [illegible] of the [illegible] of material [illegible] depended on [illegible] [illegible].

[illegible] brick works **had** been [illegible] out and [illegible] had been placed upon them. ~~[illegible]~~ ~~[illegible]~~ just [illegible] was [illegible] [illegible] ~~[illegible]~~ might be [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] caused [illegible] [illegible] [illegible] [illegible] the [illegible]. The natural shape of the bed was [illegible] ~~[illegible]~~ supposed that ~~[illegible]~~ [illegible] the bed of a brick [illegible] equal to 2 feet [illegible] ~~[illegible]~~ the [illegible] might be reduced [illegible] would be [illegible], and by [illegible] ~~[illegible]~~ the [illegible] the [illegible] might be commenced [illegible] and dip [illegible] the [illegible] [illegible].

[illegible] plan [illegible] [illegible] the [illegible] brick works that were located on the above principle, and [illegible] during the [illegible] operations [illegible] [illegible] [illegible] [illegible]

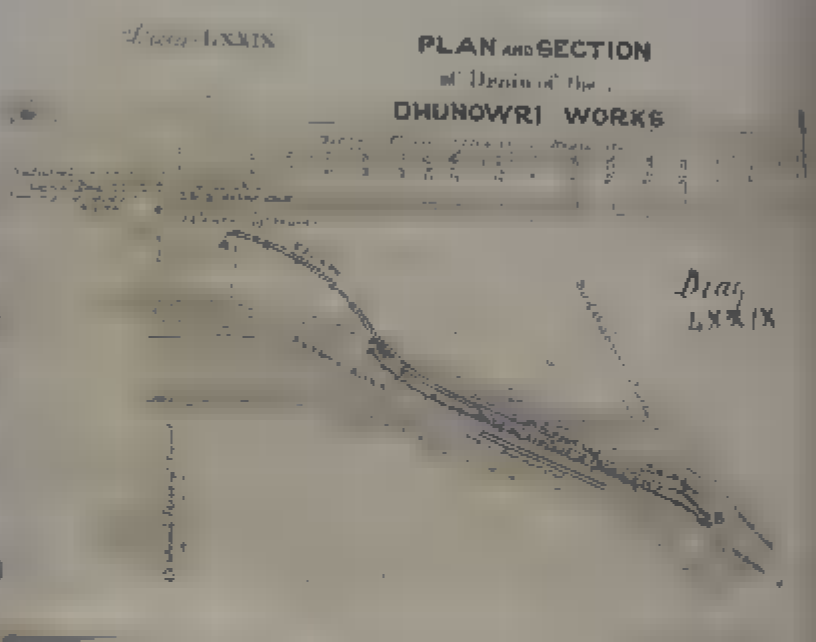
[illegible]

[illegible] 2.5 feet [illegible]
[illegible] for the [illegible]
[illegible]
in the foundations [illegible]
to a depth of [illegible] well [illegible]
[illegible] water [illegible]
[illegible] a depth [illegible]
[illegible]
thereby [illegible]
[illegible]
[illegible] the [illegible]
that [illegible]
assigned

[illegible]
[illegible] the
[illegible] of the [illegible]
[illegible]
[illegible] A. It [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible]. It [illegible]
[illegible] to a length of 10 feet
[illegible] (as the foundations
increased in depth) gradually
increased to 21, [illegible]
of 15 [illegible]. On the [illegible]
it [illegible] the [illegible]
[illegible] of the [illegible]
letter B. [illegible]
[illegible] of the [illegible]
[illegible]
[illegible]
of its [illegible]
[illegible]
[illegible]
of contact with the [illegible]
[illegible]
-[illegible]

of [illegible] [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible]
[illegible] of [illegible]
[illegible] the [illegible]
the position [illegible]
[illegible]
[illegible] to the [illegible] of the
[illegible] [illegible] of material
[illegible]
[illegible]
[illegible] the [illegible] had [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible] [illegible]
[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]



note for the printer

C. C. Drainage cut
D. D. Bund to protect drainage cut
E. E. Excavated
F. F. To be excavated
H Beddhakpoor Kalia

[illegible] ... pursuant ... [illegible] ... depth [illegible] ... [illegible]

Thereby [illegible] ... [illegible] ... polygons

[illegible] ... [illegible] ... (A.) [illegible] ... [illegible] ... [illegible] ... [illegible] ... (as the [illegible] increased in depth) actually [illegible] ... [illegible] ... [illegible] ... letter B. [illegible] ... [illegible] ... [illegible] ... [illegible] ... [illegible] ... [illegible] ... [illegible] ... depth [illegible] -pected

system was found to be used [illegible]

[illegible] to [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] and [illegible] and water

[illegible] [illegible] it was [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] the spring ~~bottles~~

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] through

which the [illegible] had to be

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] Saturated by ~~[illegible]~~

~~[illegible]~~ [illegible], [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] ~~[illegible]~~

[illegible] [illegible] found the [illegible]

[illegible] the foundation, [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] water [illegible] upon

the foundation [illegible] [illegible]

it was [illegible] impracticable [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

the [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

of [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] the

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] the

Course of [illegible] [illegible]

[illegible] [illegible] difficulties [illegible]

[illegible] [illegible], [illegible] [illegible]

[illegible] [illegible] the [illegible] [illegible],

the ultimate means [illegible]

[illegible] [illegible] [illegible].

[illegible] [illegible] point was

raise

[illegible] by the [illegible]
[illegible] and [illegible]
having [illegible]
[illegible]
[illegible] but [illegible]
[illegible]
[illegible], [illegible] the [illegible]
[illegible]
the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
and [illegible]
[illegible]
[illegible]
[illegible] ~~[illegible]~~
[illegible] the latter [illegible]
[illegible].

[illegible]
[illegible]
[illegible]
[illegible] ~~[illegible]~~ [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible] 11° 14' 10''; [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible] the [illegible]
[illegible] the [illegible]
[illegible]
[illegible]

[illegible]

three in the upstream end to [illegible]

[illegible]

[illegible] built then merely [illegible]

[illegible] wait [illegible]

[illegible] LXXIV [illegible]

[illegible]

[illegible]
B^1 B^2 B^3 B^4 [illegible] B^1 [illegible]
[illegible]
[illegible] & B^4 [illegible] with a [illegible]
[illegible]
[illegible] A^1 A^2 A^3 A^4 [illegible]
[illegible] of A^1 [illegible]
[illegible] A^2 [illegible]
[illegible] A^3 & A^4 [illegible]
[illegible] water.

[illegible] could be reduced. The [illegible] depth [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], and [illegible], [illegible] the Engineer [illegible], [illegible] [illegible] that the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] depth of 1? feet [illegible] the [illegible] [illegible], to depth of 1? feet [illegible] [illegible] [illegible] [illegible].

In [illegible] [illegible] description of the details and construction of these [illegible] works, I shall divide them into four classes –

A The [illegible] works on the [illegible] or approach up to the Dam [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

B. The Dam and its Flanks

C. The Backwall & Flanks

D. The [illegible] works on the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] and [illegible], [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible].

A. This portion of the work consists of [illegible] [illegible] varying from 100 to 7? feet in distance [illegible] [illegible]; the [illegible] 450 feet in length which [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] parallel [illegible] [illegible] the lower 350 feet [illegible] [illegible] equally [illegible] upon [illegible] 7? feet in width [illegible] parallel [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] the [illegible] down [illegible] same
cells [illegible] 31 [illegible].
[illegible] the [illegible]
[illegible] divided [illegible] the [illegible]
the [illegible] that [illegible] with the
[illegible] [illegible], [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible]. The [illegible] [illegible]
[illegible] the [illegible] [illegible] the [illegible]
in the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] to
17 [illegible] 11"

The [illegible] [illegible] [illegible]
on [illegible] the [illegible] [illegible] [illegible]
[illegible] [illegible] 13 [illegible] ([illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]) [illegible]
to a depth of [illegible]. ~~[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]~~

The division of the tomb [illegible] [illegible] [illegible] description, the [illegible] [illegible]

Right [illegible]		7 [illegible]	20 x 12
Left	do	6½ "	20 x 19
[illegible]	Bays	6 "	24 x 19
	[illegible]	4 "	25 x 17
	[illegible]	2 "	25 x 22

The dimensions [illegible] [illegible] the [illegible] [illegible] of the base [illegible] block [illegible] well [illegible] the [illegible] [illegible] being [illegible] towards the 2 ends [illegible] perpendicular and parallel to each other, the [illegible] [illegible] towards the top. Each block [illegible] [illegible] [illegible] [illegible] of the [illegible]

upon

[illegible] was
raised and allowed to [illegible]
[illegible]
[illegible]
[illegible] possible
[illegible]
to from 1½ to 2½ [illegible]
[illegible]
2 feet [illegible]
[illegible]

(33 – 41 – Vol. II.
Part III. Ch. I
[illegible])

[illegible] 60 [illegible] $10\frac{3}{4}$ [illegible] countersunk in the [illegible] [illegible] in position [illegible] [illegible] ends [illegible]

[illegible] on the left Abutment where the pressure of the earth acts in thrust [illegible] surface, [illegible] back to a distance of 20 [illegible] and are anchored in the [illegible] Shams (tools used in [illegible]) [illegible] on the termination of the [illegible] were no longer required [illegible] of this arrangement [illegible] for the purpose of giving add[illegible] strength to the abutment [illegible] Plate [illegible] Fig[illegible] 2. —

[illegible]

[illegible] to a depth of 5 feet, and [illegible]

[illegible] of the proper [illegible]
[illegible] position, [illegible]
[illegible] particular [illegible]
of the [illegible], and [illegible]
[illegible] separate [illegible]
[illegible]
[illegible] Plate XXV [illegible] 5

[illegible] the problem [illegible]
[illegible] Diagram CLXXI [illegible]
[illegible] opposed [illegible]
[illegible] A' A'
A' [illegible] A' [illegible] Diagram LXXIV [illegible]
[illegible] A' [illegible]
[illegible] A'; [illegible]
[illegible] the opposite side [illegible]

Explanation [illegible]

[illegible]

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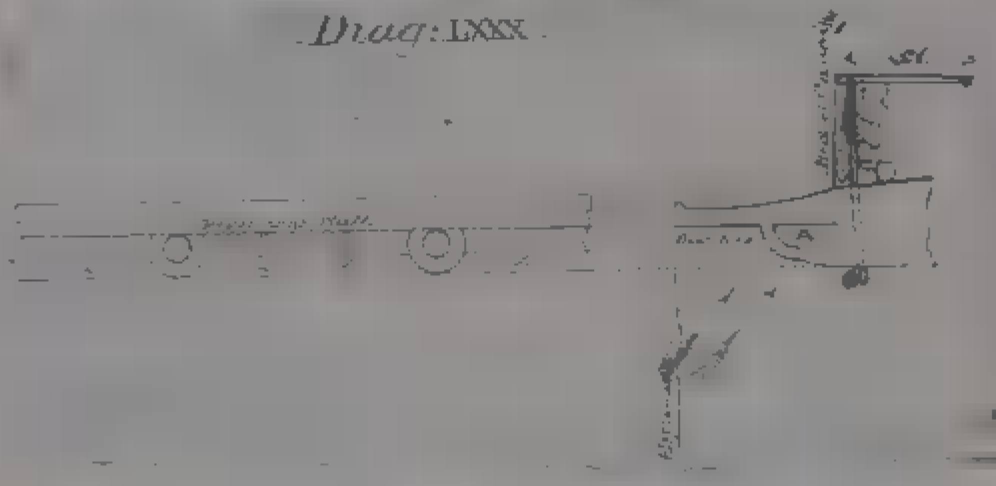
Drag: LXXX



[illegible] through the [illegible] [illegible] A [illegible] [illegible] [illegible] acquainted with agricultural drainage [illegible] practised in some English counties, [illegible] [illegible] angular fragments [illegible] percolation through the [illegible] [illegible] deposits of impervious matter, which by occupying

[illegible] the angular [illegible] [illegible] the presence of water, and that the only remedy is a periodical relief by either cleaning or renewing the fragments: an operation in the case of land drainage I should imagine leading to great trouble and expense but in that of [illegible]

5 [illegible]

[illegible] A² [illegible] A³ [illegible]

[illegible] A⁴ [illegible]

B [illegible] pains [illegible]

[illegible] the planks [illegible]
a passage constructed [illegible] massive [illegible]
[illegible] timbers [illegible]
[illegible] approach to
the [illegible]
[illegible]
[illegible] wall [illegible]
towards the [illegible]
[illegible] The [illegible]
[illegible] feet [illegible] flooring
[illegible]
[illegible] admitted
by a [illegible]
[illegible]
[illegible] 11 feet [illegible]
[illegible] sills [illegible]
[illegible] 3½
feet, [illegible] flanked on
[illegible]
[illegible]
[illegible] height of [illegible] feet, with
[illegible]
[illegible]
[illegible]. On the [illegible]
[illegible] platforms raised
to a height of [illegible] about the
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] 11 feet [illegible]
[illegible] feet, [illegible]
[illegible]

[illegible]

[illegible] Plate XXV [illegible] 5 feet [illegible]

[illegible] raised so as to avoid a strain to a depth of 5 feet from down the Canal. [illegible]

[illegible]

[illegible] a [illegible] [illegible] with
[illegible] [illegible] [illegible] [illegible] use
[illegible] [illegible] [illegible] height is 15
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
on a slope of 1 to 5
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] an
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] a
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]. [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] head [illegible] [illegible] [illegible]
[illegible] [illegible] width and 35 feet in
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible].
The [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] with [illegible] [illegible]
[illegible]. [illegible] [illegible] [illegible]
[illegible] [illegible] with [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] drop gates
[illegible] the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] apparatus
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] account.
[illegible] [illegible] [illegible] is 29
[illegible] [illegible] [illegible] 10 feet in width
[illegible] with [illegible] sills raised
[illegible] feet above the [illegible] [illegible]
[illegible] each [illegible] of these [illegible]
openings.

of the [illegible] [illegible] in width
the [illegible] [illegible] usually
put [illegible] [illegible] bath, the
[illegible] [illegible] been erected
in a platform [illegible] supported
[illegible] [illegible] 10 feet and [illegible]
[illegible] the canal, aligned [illegible]
[illegible] [illegible] ~~[illegible]~~ the [illegible]
[illegible] platform [illegible]
[illegible] with the upper 13
[illegible] [illegible] [illegible] manner
place as before described ~~[illegible]~~
~~[illegible]~~ [illegible]
[illegible] [illegible] [illegible] case is
[illegible] [illegible] 5½ feet [illegible]
[illegible] [illegible] without [illegible]
[illegible] [illegible] of sluice planks
[illegible] [illegible] and the necessary app-
paratus required for the [illegible]
[illegible] of the water. The tops of
the [illegible] [illegible] [illegible]
posts and into them [illegible]
planks are laid [illegible]
[illegible] so as to form a line of
[illegible] communication across the
[illegible] of the canal. These [illegible]
[illegible] 4 feet similar to those
in the [illegible]

The sluice [illegible] [illegible]
gates [illegible] [illegible] side posts
[illegible] [illegible] [illegible] to the
[illegible] they are 8' 8" [illegible]
[illegible] [illegible] [illegible] to the
[illegible] [illegible] [illegible] the frame
It is supposed that the pass-
ing [illegible] [illegible] to the
canal [illegible] [illegible]
from the [illegible] [illegible] [illegible]
gates [illegible] [illegible]
[illegible] [illegible] the usual [illegible]
[illegible] adopted by the [illegible]
[illegible] of [illegible] [illegible]
[illegible]

[illegible] [illegible] these [illegible]
[illegible] [illegible] the [illegible] side
[illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] of the water would
~~[illegible]~~ [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] set of
[illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] of [illegible] [illegible]
in the [illegible]. [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible]
of the [illegible] depth [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible]. [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible]. It will be [illegible]
that [illegible] of the [illegible] [illegible]
[illegible] [illegible] [illegible] depth [illegible]
in the canal [illegible] be [illegible].

[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible], which
[illegible] [illegible] [illegible], [illegible]
on the [illegible] River, I must
[illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible]
III [illegible] [illegible] it [illegible] [illegible],
that the [illegible] [illegible] [illegible]
[illegible] at the [illegible] [illegible]
[illegible] [illegible] [illegible] the [illegible] is
[illegible] [illegible] 3 feet [illegible] [illegible] 1.87
[illegible] for 100 [illegible] [illegible] [illegible]
[illegible] [illegible] transverse [illegible] [illegible] line
[illegible] through the [illegible], and
[illegible] [illegible], and [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
would be equal to 3012 feet, [illegible]

that the [illegible] of [illegible] of the [illegible] at a distance of 30463 feet from [illegible] [illegible] [illegible] with a slope [illegible] per [illegible] [illegible] 3 [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible], that [illegible] [illegible] [illegible] with the slope [illegible] [illegible] [illegible] to be [illegible] x 3·045 or 5·6 [illegible] that [illegible] the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] at a [illegible] [illegible] [illegible] [illegible] to reduce the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in [illegible] [illegible] [illegible] shutting the gates, the increased velocity of [illegible] at this particular point [illegible] [illegible] the passage of [illegible] [illegible] almost [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with reference to the [illegible] slope [illegible] [illegible] [illegible] the [illegible] [illegible] the height of the sluice [illegible] the sills of the [illegible] [illegible] raised 24 inches above the [illegible] level, that of the 4 [illegible] [illegible] with the [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] or 10 [illegible] [illegible] [illegible] the [illegible] for the gate [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible] the sills of the 4 [illegible] [illegible] [illegible] [illegible] [illegible] will be [illegible]; 1st a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] shutting the sluices; 2nd a [illegible] [illegible] [illegible] a depth [illegible] [illegible] [illegible] [illegible] that

[illegible] a supply of water will flow down the Canal in [illegible] of [illegible] [illegible] works [illegible], [illegible] to [illegible] the [illegible] [illegible] [illegible] at [illegible] [illegible] of the [illegible] [illegible] between [illegible] that [illegible] the [illegible] will [illegible] [illegible] of [illegible] that [illegible] the Canal [illegible] which will include the [illegible] [illegible] [illegible] a [illegible] by the [illegible] that attached to the [illegible] with [illegible] will [illegible] [illegible] that the [illegible] consequences may be [illegible] levels that [illegible] which flows with the least [illegible] [illegible] us that the [illegible] which crosses the Canal channel will [illegible] the body of water that comes down the Canal, that this latter will [illegible] a [illegible] with considerable action on the works round the [illegible] and [illegible], with [illegible] [illegible] and [illegible] the [illegible] [illegible]. It is impossible to say to what [illegible] of the [illegible] to the deposition of [illegible], and in contemplating the

[illegible]

[illegible] [illegible] [illegible] value
less degrees, & are liable to [illegible]
[illegible] insecure than the
foundations [illegible] at
the particular points alluded
to. But if we raise the bank
[illegible] to a [illegible] height that
[illegible] [illegible] may be looked
upon as [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] to the
[illegible].

[illegible] of the banks
adjacent to the [illegible] equal
to those described under the
Division C are protected by
spurs ~~[illegible]~~ consist-
ing of piles driven [illegible] feet deep
[illegible] at distances (feet
apart [illegible] the plan) at the
foot of the bank [illegible] the [illegible] of
the [illegible], and [illegible]
of the [illegible] near to that
of the [illegible]. The intermediate
spaces being filled with [illegible]
[illegible] [illegible] [illegible]
with [illegible] [illegible] upon
[illegible] the piling. The spurs
on all occasions diverge out-
wards from the bank to a [illegible]
[illegible] depth [illegible]
[illegible] [illegible] of the banks
on the upstream side towards
the [illegible] are well protected
by [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]

D [illegible] [illegible] the [illegible]
[illegible] the [illegible],
[illegible] with the [illegible]
and [illegible] [illegible]
of the foundations [illegible] the purpose
[illegible] [illegible].

The

The works of these locks are provided [illegible] Gates which come under the following enumeration.

Regulating Bridge	6 pairs	35 x 9.2
do. do.	2 do	35 x 15
1. Upstream lock [illegible]	4 do	15 x 15
2. do. Lift	do [illegible]	15 x 1[illegible]
Downstream lock	[illegible]	[illegible] x 15.0
do. Lift	[illegible]	[illegible] x 13.0

The method of working the sluices will appear to be [illegible] to [illegible] before described.

The [illegible] Structure of the [illegible] [illegible] [illegible] [illegible] walls which [illegible] the flanks of the [illegible] and the right and left of the [illegible] of the Regulator [illegible] on the [illegible] of the Bridge [illegible] communication which lies on the left of the [illegible] [illegible] corresponds both in width and dimensions. On the down stream side of the regulating bridge, the lines of the [illegible] channel are indicated by [illegible] lines of masonry walls [illegible] along a flight of steps [illegible] to the [illegible] walls from the [illegible]. The [illegible] of these walls is equal to the [illegible] of the [illegible] the [illegible] [illegible] immediate contact [illegible] with a flight of steps. [illegible] approach the [illegible] channel [illegible] under drainage from the [illegible] of the [illegible].

[illegible] to the width of [illegible] the present [illegible] is only [illegible]

the Regulating [illegible] [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] 10 bags of 2 [illegible]
[illegible] [illegible] [illegible] in the apparatus
[illegible] [illegible] [illegible] [illegible]
of the [illegible] from the plate, a
[illegible] [illegible] [illegible] the [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] of the
[illegible] [illegible] the apparatus [illegible]
[illegible] [illegible] [illegible] to the
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] a [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] detail.
[illegible] [illegible] the [illegible] is C and
[illegible] [illegible] through the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] to the [illegible] [illegible]
[illegible] through that part [illegible]
[illegible] and [illegible] Regulating
[illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] that [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] for the [illegible]
of the [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] that [illegible] [illegible]
[illegible] through the [illegible]
the [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] escape
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] is above ~~[illegible]~~
~~[illegible]~~ [illegible] [illegible]
[illegible] [illegible] I have [illegible]
described is [illegible] feet in breadth and
with a height from the floor to
the

the width of 5½ feet are connected
with these passages which leave
the Abutment at right angles
to its face. These passages are
separated by a pier 4 feet in width
and they descend on a slope [illegible]
of [illegible] in a length of 120¾ feet
to a flooring situated at the point
of contact with the Abutment,
at a depth of 7 feet below the level
of the Canal bed. From this point
the flooring is carried under that
of the Bridge on a horizontal
level until it terminates in the
excavated channel ^x. These passages
meet the bridge alignment by
a curve tangential to the angle
of approach; they leave the
bridge on a similar curve after
passing under the Canal channel
and continue on a tangential
line for a distance of 159 feet
in which space the Canal em-
-bankments lying on the left
are passed. ~~These subterranean~~
~~passages~~ they then open out into the
channel excavated for the pur-
-pose of carrying off the water.

These underdrains are
approached both on the up and
down stream sides of the bridge
by passages built in connection
with the Revetments, access to
the channels themselves being
gained by flights of steps. Man
holes or cylindrical wells of [illegible]
feet in diameter are carried
perpendicularly through the
piers and abutments the top
covering ~~[illegible]~~
the bridge roadway being covered
[illegible] stone slabs [illegible]

x [The] width of which is 20 feet with [a] slope of 3'44 feet per mile

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Sup. I. [illegible]

-ings are the means of ven-
-tilation. To each pier and +
Abutment 2 of these holes are
given, and it is supposed that
they, together with the flank +
passages, will provide sufficient
means for clearing the channels
from deposits.

The plan for using these
channels ought to be as follows.
During floods their heads would
be entirely closed, the shutters
would be down, and no access
to the flood water would be
permitted. It is only at periods
when the Autumn [illegible] that these drains
would be brought into use,
during the period the shutters
would be raised, and the
mouths of the channels would
be kept free and open. The
working parties of Beldars
attached to the Regulator would
do all in their power to conduct
the stream of the River (which
during the dry season is moder-
-ate) as well as water coming
from the works, to the mouths
of the drains; rubbish in the
shape of branches and trees
ought to be prevented from ap-
-proaching the Drain head,
and it might be necessary
as a greater preventive to its
admission to guard the open-
-ings by Iron gratings. –

It is indispensable that
during floods the drains should
be thrown out of use, otherwise
should any worse accident happen
they

they will inevitably be choked up. Whether it may be convenient at any time to attempt a scour by forcing a current of considerable volume through these drains for the purpose of cleansing, may be left for after consideration; that they will require periodical clearances is certain from the disposition of the slopes of the flooring, but it is hoped that whether by the means of access now given for the object of clearance, or whether by occasional scours of water drawn off from the Canal, these Channels will be found capable of performing the duties for which they have been designed. I need hardly advert to the extraordinary value that the efficient maintenance of these Channels as free water passages possesses for benefitting the works at this particular point, and the influence that it will have on the salubrity of the neighbouring country. I have no hesitation in recording my opinion here, that the decision which attended the vigorous measures for drainage on these works, and which enabled me to carry out the design for the main channels which I have above described, is amongst all the arduous and difficult operations which have ~~atten-~~ happen- ~~upon~~ -ed the execution of the Khadir works, that [illegible] others, which has given me the greatest

greatest satisfaction, and which has relieved me from one of the greatest difficulties.

Having now thus described the whole of the works at the Kutnoo Dam, in a way which with the plans, I hope will be sufficiently clear, I will now give as concise an account as [illegible] of the cost, material used in the construction, and the rules [illegible] by the Executive [illegible].

I have before mentioned that the ground both with [illegible] of the works the [illegible] and to the brick fields in the neighbourhood, was [illegible] laid out by Mr Logan, to whom [illegible] to [illegible] the [illegible], particularly [illegible] adapt them [illegible] convenience; the ground plan is shown in Diagram LXXV; The brickmaking was under Mr [illegible], the Executive Officer of the Material Department.

The sizes of brick used were 10" x 6" x 2½" and 9" x 4" x 3", the former being burned in the English, and the latter in the Native kilns. The latter I have before said were made in one of Mulli's brick making machines.

The whole of the Kutnoo works are built with brick, with the exception of the massive parts of the foundations [illegible] boulders brought from the [illegible] the [illegible] are [illegible]. The [illegible] material placed in conjunction with the [illegible]

and box work, for the protection of the works, was of Kunkur stone. The Lime was of the best description and similar to that used invariably in the Khadir works, made from Lime rock either burnt in the Dehra Valley, or from Lime boulders collected in the bed of the Ganges.—

The proportions of materials used in Cement were as follows

Mortar		1. Lime [illegible] 2. Soorkee [illegible]
Plaster	[illegible]	1. [illegible] 2. [illegible]
	[illegible]	3. [illegible] 2. [illegible]
		[illegible]

The total amount of materials is shown in the following table, to which is appended the rates of the different species of work which has been executed.

Total Content of masonry 1496463 Cubic feet

Materials Expended

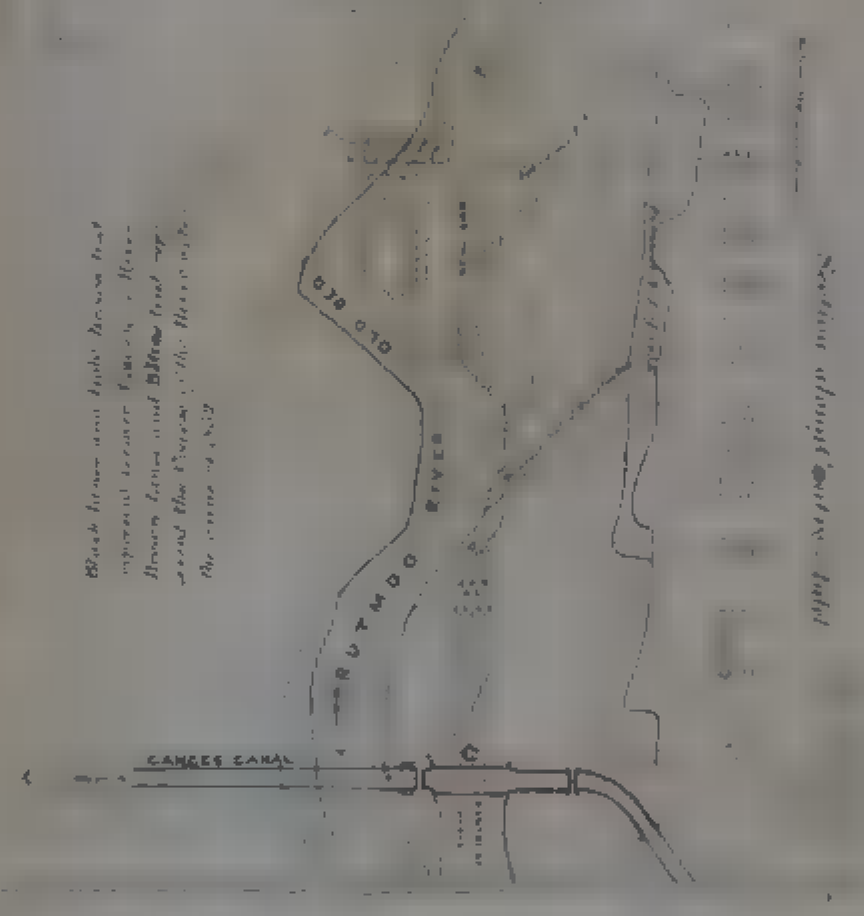
Bricks — 12" × 6" × 2½"	12134613	
— Do — English Machine	813832	
Boulders	126125	Maunds
Kunkur	20964	Cubic feet
Stone Lime	208981	Do
Soorkee	397906	Do
Plain Masonry	16 13 –	per 100 cubic feet
Brick on edge — do	20 9 5	per do
Arch — do	19 6 –	per do
Plastering	2 3 7	per 100 [illegible]

The noses throughout the works at the Outlet have been protected by Kunkur stone, and in all cases where the working of the gate or sluice apparatus was likely to injure the masonry stone has been used. The material is brought from the quarries in the

the Aqueduct and is altogether of a superior description to the English work. In conclusion I may observe that the whole of the brick work is stuccoed on its external surface, with a thin layer of lime cement.

Previously to the rains of 1852 it was considered desirable to commence operations on the River to prevent towards its change of course upon the works. For this purpose 3 cuts represented in the following diagram were made in prolongation and parallel to the axis of the works across a bend in the River.

Diag: LXXXI
Showing how the arrangements made prior to the Rains of 1852 affected the course of the
RUTMOO RIVER



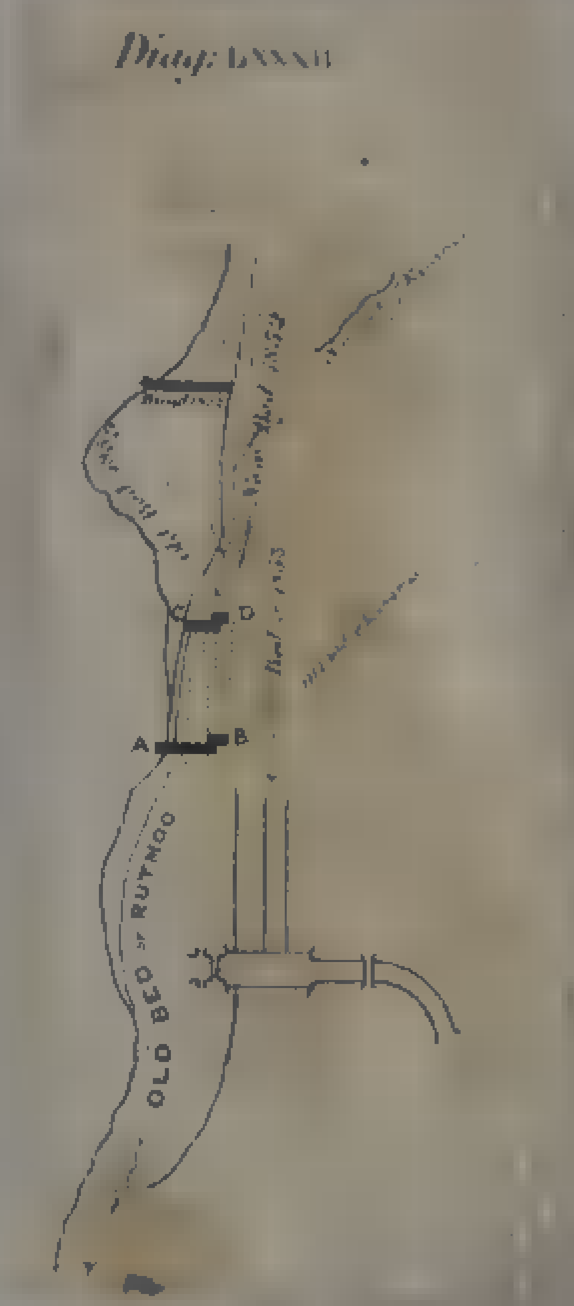
The effects after the rains of 1852 are shown on the face of the diagram. ~~[illegible]~~ The arrangements were well in advance and so far as the straightening of the course of the River was attempted, they were successful. In 1853 and in preparation for the floods of that

that year, the Masonry works being sufficiently advanced to admit of water being passed over them, the 2 Cuts above alluded to were prolonged to the Inlet, or in the above Diagram from B to C. At the early part of the season there was some difficulty experienced in persuading the flood water to leave its old channel, and to follow the direct course which was opened out for it. This partly arose from the insufficiency of waterway at the heads of the newly excavated cuts at B, and partly from the natural tendency that the slopes of the bed gave the current towards its old direction. By opening out of the heads of these cuts, however, and by a judicious application of bunds and spurs, the River was ultimately conducted over the masonry works and trained in the new line upon which it will now flow. It has been before explained that for the maintenance of the current in its direct course upon the works, as well as for other purposes in connection with deposit and the improvement of the low land lying above the Inlet, I proposed the application of parallel lines of bunds or low embankment across the valley situated at right angles to the current itself, and constructed on the same design as that which had been adopted for similar purposes [illegible] of the Puttee. — By continuing

[illegible]

with the temporary bund work necessary for the turning of the course of the River, the construction of the permanent parallel Embankments which were part of the original design, the operations appear to have been carried on very successfully, and I cannot do better when stating the success that attended upon these operations than in giving the Engineer's own account of his progress.

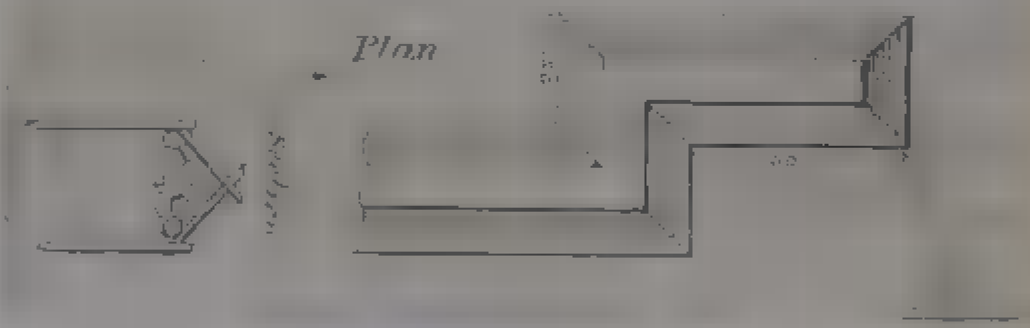
Diag LXXXII.



The above diagram shews the state & position of the River in the month of July 1853 at a period when the most active measures were being undertaken for turning the course of the River into the works. At the points B C D there is high ground situated

situated in the bottom of the bed of the river, at the highest point D [illegible] established the inner of one of the permanent embank--ments similar to that at the Jetties and in shape and di--mensions as follows:—

Diag. LXXXIII.



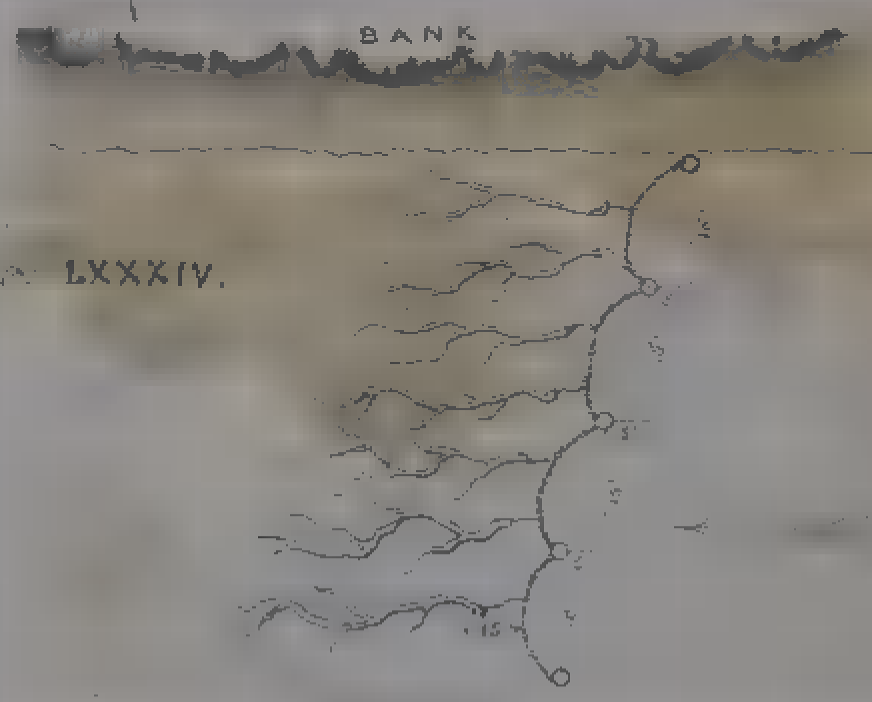
the triangular superstructure being made of timbers or spurs 15 feet in length, attached apron of material at the jetties and necessary protection were also made. The upstream salient end E was left as open passage for the water to break upon and the rest was filled with [illegible] brick and masses of [illegible] burnt material brought from the brick fields. By the above arrangement the current was forced round the head of the spur [redacted] and by creating an impediment by the same set at B, was urged into the head of the cuts which had been [illegible] -dered and to remove it. Mr Logan [illegible] describes his disap--pointment in the failure of a spur which was thrown out in the early part of the rains of 1853 at the [illegible] E, observes that "it struck me that where [illegible] "the use [illegible] piles and [illegible] "transfer [illegible] trees and [illegible]

"their heads, having the natural
"tendency [illegible] at a distance of
"25 feet or thereabouts in their
"down stream [illegible] so that which
"the poles would be protected from
"cutting immediately in their
"neighbourhood I might get the
"sand to silt up and form a bank at the spot in question. For this
"purpose I procured some of the
"chains used in block sinking and
fastened a quantity of jungle in the
"way above mentioned &c.)

Diag: LXXXIII.

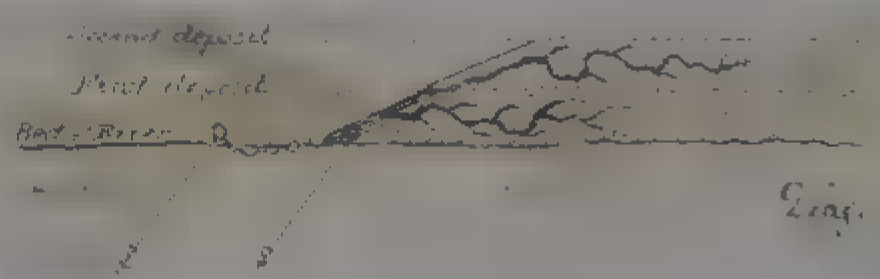
"[illegible] only
"[illegible] piles available 12 feet in length
"each, with [illegible] inches in
"diameter. These were screwed
"down into the bed of the river
"with their upper ends just
"below the surface, to these the
"material was attached. A few
"nights afterwards a small flood
"came down the River, and to my
"great astonishment when I visited
"the spot the morning afterwards
"I found that [illegible] these [illegible]
"piles [illegible] equal in length
"to 30 feet and a breadth of 50
"had deposited itself in the form
"of a bank [illegible] completely
"[illegible] the whole of the jungle
"which had been attached to the
"pile heads, leaving this "in hopes
"[illegible]" I immediately had
"a number of the screw piles
"made and instead of fixing
"the jungle by long [illegible]
"[illegible]
"the piles in the following
"[illegible] passing the chain
"through the [illegible] at their
"heads and [illegible] the jungle
by

[illegible]:—



diag. LXXXIV.

the effect of sedimentation on [illegible] [illegible] [illegible] [illegible] [illegible] the water which would decidedly hinder [illegible] that [illegible] [illegible]. ~~[illegible]~~ [illegible] that by additional layers of brushwood after each flood, ~~[illegible]~~ the sand bank where to be raised to a height above the mark of floods, [illegible] by the means [illegible] a defence of much greater stability than that made by nature itself out of pure sand; ~~[illegible]~~ ~~[illegible]~~ that is shown by the following diagram:



Diag. 85.

Note for Printer
The black is mottled for the words
"Second deposit" "first deposit" & "bed of river"

"The deposits" [illegible] says
"[illegible] [illegible] had raised
"the height of the natural
"bank [illegible] the river
"and by extending the use of
"the [illegible] [illegible]
"[illegible] [illegible] [illegible]
"[illegible] [illegible] upon the
"[illegible] [illegible] [illegible]

"be no deviation from it hereafter"
The adaptation of the Screw pile (Mitchells) to the particular purpose to which it had in this case been applied is most undoubtedly a great accessory to our river works, it is in fact using the pile for mooring purposes for which it appears to me to be the most appropriate.

Dear [illegible]

II. [illegible] in relation to the admission of Country Drainage

It will be understood from what has been written in previous chapters, that the Canal after it reaches the high land [illegible] proceeds in a course as nearly as closely as possible to the summit levels of the country. Whether in its main trunk or in its branches, the direction pursues an uniform course between the limits by the watershed to which it is intended guided. The position of the Canal channel is on the summit of a ridge which separates the drainage of its two boundary Rivers, above whose beds it is [illegible] elevated. The beds of the boundary rivers are naturally, as they ought to be artificially, the best outlets for drainage, and it has been a leading principle throughout the work design to protect the canal channel as much as was possible from the inlet of country

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country water, and to throw the drainage away from the works, rather than to give it any encouragement to approach near them. In all cases where the irregularity of surface drainage, and the tortuous course of the natural watershed, have been intersected by the straight alignment of the Canals, measures have either been taken or are to be taken for the effective relief of the flood water by cuts made into its neighbouring river. In no case ought this rule in my opinion to be deviated from; the beds of the natural rivers ought to be considered as the true escapes, and the Canal Channel ought to be confined to its own especial duties. My views of the equilibrium that will be maintained in the surface water by the connection of the main Canal and its branches with the subordinate lines of Rajbuha have been fully entered into in the Chapter describing the Rajbuhas, and their double objects of Irrigation and safety valve. It is sufficient to advert here to the fact that during rain the amount of water collected by direct incidence, as well as that poured into the Canal Channel through the bridge inlets which from their position it may be noticed are capable of being entirely restricted to the Rajbuhas themselves, will add sufficiently to the supply of water passing down the

nel, and with the relief afforded by the escapes, to render any superfluous inlet (especially when such is avoidable) unnecessary.

The works that come under this section are distinctly inlets for the reception of flood water from extensive areas of country; they are directly connected with the excavated Channel, and they are confined entirely to the tract lying above Roorkee. With the exception of the Pounda Sookni wala & Kunkhal drainage, which, however, is more connected with sloughs, than with sandy bedded rivers, the water which is admitted through these Inlets is that which falls upon wild and uncultivated surfaces lying at the foot of the Siwaliks, and it is free from the sand and silt which characterises the ~~mountain~~ torrents whose heads are within ~~[illegible]~~ the mountains.

Of these works, there are five, viz.

		width of waterway
1st	The Pounda Sookni wala Inlet	50 feet
2nd	" Kunkhal "	30 feet
3rd	" Jowalapoor "	100 feet
4th	" Selimpoor "	150 "
5th	" Badshahpoor "	50 "

With the exception of the works at Kunkhal, which varies in some respects, the design of these inlets is uniform; it is a combination of an inlet or flume with a passage for the tides of floods, the flight of steps being available for access to the canal water for bathing.

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bathing, or for other purposes.—
The sills or upper steps are in all
cases retained on a level either equal
to or above the maximum supply
water mark in the Canal, and
the flood water on its admission
passes over the flight of steps,
and is retained within its limits
by plank walls.—

The local depression of
the Country at [illegible], at
the site where the Inlet is con-
-structed, rendered it necessary to
modify in a slight degree the
plan which has been elsewhere
adopted; the modification will
be understood by referring to
plate XV. [illegible] of the Atlas, it consists
in a sluice fixed vertically in
the flight of steps, so as to admit
of the flood water of the country
passing into the Canal at low
levels, when by the closing of
the Regulator at Mayapoor the
channel is comparatively dry.
This sluice is fitted with some
planks or stoplogs, in the way
which is usually practised
elsewhere.—

These works are built al-
-most entirely with boulders
(River stones) collected in the
bed of the Ganges and its branches,
they are faced with brick, and
the use of this material is ex-
-tended to all parts, where ex-
-ternal finish is required, or
where the application of lines
of brick masonry was considered
to give additional stability to
the structure.— The outer [illegible]
is [illegible], and made of [illegible]

[illegible]

uniform appearance by a coating of plaster. The whole of these works are designed on a scale of solidity, adapted to the rough work which they will have to undergo; they are strongly protected both on the upper and lower levels by piling and boxwork, and no means have been spared to render them as efficient as possible. —

It is unnecessary in this place to advert to the causes which led to the construction of these works as they have been fully entered into in a former chapter, it may be sufficient here to repeat that they are confined entirely to the regions connected with the mountains, and to parts of the country where the line of the Canal by running at right angles to the natural slope ~~of the country~~, intersects the drainage. The breadth of waterway which has been given to each of the Inlets, will, it is believed, reduce the action of the current and render its effects upon the works harmless, and considering them as masonry Ghats for giving access to the water, their introduction at detached points will undoubtedly be of great convenience to the people in the neighbouring villages. —

The rates or cost of building will be shewn by the following table

[illegible] bricks in Masonry —	15	2	8	pr	100 cubic ft
[illegible] — Do —	13	12	8	pr	—
[illegible] from — Do —	14	3	1	pr	—
[illegible] from — Do —	15	1	.	pr	—
[illegible] from — Do —	14	3	.	pr	—

The cement which is used in the body of the work consists of

1 Part Stone Lime
1 " Soorkee

The Stucco or plaster of
2 Parts Stone Lime
1 " Soorkee.

III. The Works on the Ganges Canal for the Escape of Country Drainage.

The works for this purpose are as it will be understood from the description of them, of an exceedingly limited nature; they are in fact confined to the Masonry outlet, and an arrangement, to which I have drawn attention when describing the Ranipoor Inlet, for permitting flood water to pass over the Canal Channel through openings left in the embankments immediately opposite the inlet in question.

In regard to the first which is situated on the left bank directly opposite the Kunkhul Inlet, its principal object is to dispose of the water received from that source without adding its quota to the sufficiently inconvenient supply which the want of escapes on the line from Jwala-poor to the Rutmoo river, ne-

cess

-cessarily a Fleet with the Canal be avoided. Its waterway is in 2 bays of 10 feet each giving a free escape of 20 feet, the sills being on a level with the Canal bed, and the soffit of the Arches raised to a height of 11.34 feet above it. The openings are regulated by sleeper planks worked in grooves. Independently of its use as an Escape for floods, the outlet acts as the head of a line of irrigation that extends along the high land boundary on the right bank of the Ganges; it also provides a supply for mill purposes.

Boulders are used in the foundations and massive parts of the building, whilst brick masonry constitutes the super-structure; its plan, sections &c are shown in Plate XVI of the Atlas.

The total quantity of material used, and the rates of cost of the building are shown in the following Table.-

Materials Expended			
Bricks	12" x 6" x 2½"	45075	
Boulders		13361	Maunds
Stone Lime		4310	Cubic feet
Soorkee		4220	"
Masonry	Rs	13 12 8	pr. 100 cub feet

The proportions of material in the cement is as follows.

1 Part Stone Lime
1 " Soorkee

Those of the stucco or plaster are

2 Parts Stone Lime
1 " Soorkee

The outlet was begun and completed by McKay, the Assistant Engineer on these works, under the supervision of Captain Goodwyn —

The gaps or openings which have been left through the embankment opposite the Chimpoor Inlet are 300 feet in width. They are merely intended to act as safety valves in the event of extraordinarily high floods to which from the height of the dike from the bed of the river [illegible] they are alone adapted; they are protected by piling and stonework, and although it is possible that these adjuncts may never be brought into requisition, they may in a case of emergency be the means of doing good service: it will be understood however that the benefit that arises from these escapes in relieving the main channel from excess of flood water will, although in a degree comparatively trifling, be negatived by their effect upon the navigable Channel, which will ~~would naturally~~ be a sufferer in a greater or less degree: the alternative, however, is a convenient one, and as such may be considered as an useful appendage to the design. —

Before closing the subject of Escape, I may remark that the Navigable Channel itself as well as the Mill line offer in a small degree the means of relieving the main Canal

under

under extraordinary pressure of water. It would not be advisable in ordinary cases to divert either the one or the other from the specific uses for which they were intended; the same species of flood, however, that brought into use the escape afforded by the gap in the Solanipoor embankment, might render the other worthy of consideration. I mention them here as a species of possibility, without the slightest desire or wish of seeing the alternatives practised.

IV. The Superpassages for carrying the Ranipoor and Puthri Torrents over the Canal.

The term Superpassage has been applied to works on the Canals in these provinces, which convey drainage water over the channels, by well protected and parapetted masonry passages. In contradistinction to aqueducts which carry a perennial supply and are built for the purpose of a regular flow of water, the superpassage merely acts as a water course during floods, and at other periods is subservient to all the purposes of cross communication. On a small scale works of this description are in common

use

[illegible] in the Deyra Doon, and [illegible]
torrents [illegible] in the
neighbourhood of the ridge of
low mountains through which
the Canal channel is carried on
the approach to the City of Delhi
these were until lately numerous
works of this kind, as well as the
double superstructure of bridges during the
[illegible] season and passages
for the flood waters from the
mountains during the rains.

The works which had to
be adopted of this description
for the Ganges Canal, have
been fully explained in Chapter
II part II of this history, and the
necessity for their adoption, and
the great difficulties and
greater expense which it entailed
upon the Government, have been so
fully described, that I shall not
refer again in this place to
details of design and construction
and to the extent and character
of the catchment basins which
are dependent upon the super-
passages for their through drain-
age.

The works which come
under the above denomination
are required to be [illegible] and
they have been constructed espe-
cially for the passage of the
Ranipoor and Puthri torrents.
The catchment basins or areas
comprised within the limits of
the total area of these lines of
drainage may be considered
as about 80 square miles.

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~~[illegible]~~ [illegible]. Each of the [illegible]
[illegible] torrent averages in width

6/0

[illegible] of Huron [illegible] line of the Batture is 2 miles [illegible] with an average depth of 16.7 [illegible] the [illegible] of [illegible] the Canal, it is [illegible] impracticable [illegible] any [illegible] the [illegible] accurate [illegible] of [illegible] which [illegible] for all [illegible] purposes [illegible] out [illegible] sufficiently accurate [illegible] the value of the average [illegible].

The [illegible] of all the [illegible] which [illegible] the [illegible] of land the [illegible] of which [illegible] on the [illegible]. [illegible] that [illegible] distant from the Canal is occupied by a low [illegible] mountain, the highest points of which are [illegible] 500 to 1000 feet above the level on which the Canal is situated. [illegible] the [illegible] of the [illegible] and [illegible] area is thus occupied, the remaining half being on a [illegible] slope towards the [illegible] of the Canal and having its surface covered with either grass or [illegible] trees, [illegible] and [illegible] been a very small [illegible]. The soil [illegible] consists of [illegible] alluvium, strata of clay, sand and [illegible] [illegible] and [illegible].

Ganges; this accords with the conclusion that portion of the Siwaliks which is in contact with the Doon and the [illegible] [illegible] [illegible] the latest showing its steepest plane [illegible] [illegible] the direction [illegible] is [illegible] the inclination [illegible] [illegible] being to the South West. These hills are subject to constant denudation, sometimes huge precipitate masses broken off from cliffs into the beds of the streams, by this and other the detritus is carried forward and spread over the plains lying at their foot. These plains which as I have before said [illegible] sloped although gradually to [illegible] [illegible] the direction [illegible] [illegible] [illegible] the conclusion that [illegible] from the mountains deposited according to the gravity [illegible] and though forming the slopes of the upper [illegible] lies [illegible] [illegible] regions. It is on this [illegible] that the Ganges Canal has been excavated, and it is in that [illegible] [illegible] [illegible] that the works I am now about

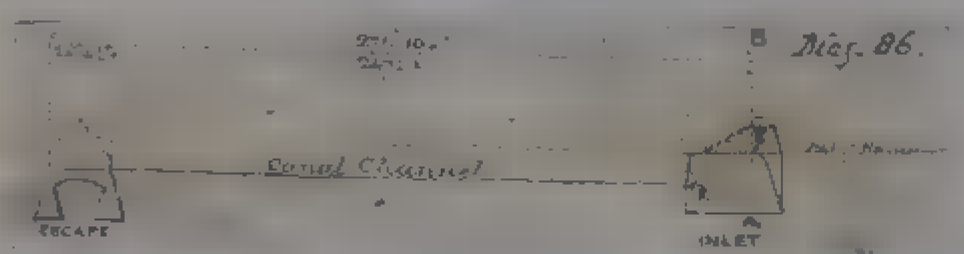
describe have been built — [illegible] the Works in their order precedence those connected

with the [illegible] [illegible] just come under review.

The Cawnpore [illegible] [illegible] and [illegible] connected

with 7 –

It is found where this work is contemplated only reference to the project of 1886 masonry siphon and inlet works built for the admission of the [illegible] and [illegible] its escape — — — — — — had been built, the former on the right, the latter on the left of the Canal channel. The [illegible] works [illegible] placed [illegible] in an [illegible] point of view on the [illegible] it being desirable to [illegible] as far as it was possible the [illegible] and [illegible] the new works. The [illegible] for the passage of the canal water [illegible] clear [illegible] feet in width, a [illegible] 16, and a [illegible] 10. It was essential that the flood water of the [illegible] should pass over the work of these [illegible] without any [illegible] interference. The [illegible] section of the Canal near the old masonry works is shown in the following diagram



Man[illegible] the [illegible] of the [illegible] AB [illegible] of the right Bank

a [illegible] in progress new build-
ing, the space [illegible] for wa[illegible]
[illegible] 6" + [illegible] or a [illegible]
[illegible] 1. 10½". [illegible] of the
required channels to meet the
above width was arranged as
follows: commencing [illegible]
[illegible] diagram.

[illegible]	[illegible]	[illegible]
[illegible]	30	[illegible]
[illegible]	[illegible]	[illegible]
[illegible] channel	19	[illegible]
[illegible]	32	6
[illegible] Openings [illegible] Channel	200	[illegible]
Total width	[illegible] 1. 10½	

[illegible] the [illegible] of the [illegible] [illegible] of 12 [illegible] brought into use as abutments to the [illegible] into which they were without any further modifications. [illegible] will be understood by a [illegible] to plate XIX [illegible] which [illegible] the plan of this work in all its details.

[illegible] in the [illegible] navigation [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and the [illegible] [illegible] and the passages [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of a [illegible]

[illegible]

ment is a large dissipation has been drawn between them and the body of water in the main channel; it becoming therefore unnecessary in the description of these works, to note that the locks are eight in number, for the passage of the main channel [illegible] [illegible] is equal to that of the [illegible] Canal, the piers having a [illegible] [illegible] to [illegible] with the [illegible] which the [illegible] [illegible] [illegible]. The locks [illegible] are [illegible] with a [illegible] [illegible], [illegible] into chambers [illegible] equal length with [illegible] [illegible]. [illegible] which [illegible] on the [illegible], and is [illegible] was built upon [illegible] with [illegible], [illegible] width [illegible] [illegible] [illegible] a [illegible] to [illegible], [illegible] 1910 to the [illegible] of the flow. At [illegible] [illegible] of the [illegible] piles the upper [illegible] of the [illegible] are filled with [illegible] [illegible] of [illegible] the chambers a [illegible] [illegible] by projecting the [illegible] in the [illegible] of a [illegible] water to the [illegible] [illegible] walls. The foundations of the upper and lower levels are protected by [illegible] and [illegible] with the former to a width of 10 feet the latter to a width of 70 feet. The [illegible] also [illegible] [illegible] are [illegible] protected, and [illegible] attention has been [illegible] to [illegible] the [illegible] foundations [illegible]

cont.

any Canal Channel [illegible]
[illegible] the protection [illegible]
consist of loose boulders
[illegible] position by wooden [illegible]
[illegible] requires constant watch-
ing, and repair, and the Canal
ought never to be laid dry, with-
out an enormous [illegible]
[illegible] not only to those [illegible]
[illegible] works, but to
all those which are [illegible]
situated.

The upper [illegible]
of the Deep passage itself are
in [illegible] the highest measurement
that is to say [illegible] the [illegible]
the [illegible] equal to 3 [illegible]. The
parapets of the right and left
are [illegible] and [illegible]
back they are continued inland from the
body of the [illegible] to a distance
of 100 feet on each side, [illegible]
[illegible]
the [illegible]
[illegible] to [illegible] from the Deep
passage.

The plan which has been
adopted for [illegible]
the [illegible] both [illegible]
and [illegible] of the
[illegible] upon the Deep passage
[illegible] is shown in Plate XIX
[illegible]. The great object has
been to bring [illegible] upon
the [illegible] by a gradual process,
and to avoid as much as possible
the abrupt contact [illegible] the
[illegible] bearing upon the [illegible]
of the passage, and to prevent
as much as possible [illegible] tend-
-ency to lateral action. The
works [illegible] exhibit the
plans that have been adopted
for

of the purposes [illegible]
[illegible] countries which
[illegible] are now discussing, which are
however equally well adapted to
the [illegible]. The present
design [illegible]
[illegible] is that which [illegible]
[illegible] experience in [illegible]
[illegible] considered the [illegible]
[illegible] efficient. The [illegible]
[illegible] have been laid
out [illegible] circumstances
would [illegible] and [illegible]
[illegible] demonstration
which [illegible]
[illegible], but [illegible]
[illegible] usually [illegible]
[illegible]
[illegible] have
[illegible] the discipline
[illegible] description I have [illegible]
[illegible] hesitation, and
[illegible]
[illegible]
[illegible]
[illegible] to deal with
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] applicable to
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] to start from the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] proved unsatisfactory
~~[illegible]~~, it
is wise to adopt those measures
which have the guarantee of
successful

successful experience. I have [illegible]
[illegible]
admitting [illegible]
[illegible]
[illegible]
[illegible] from the fact [illegible]
[illegible]
[illegible] accessories [illegible]
[illegible]

The plan which I have just [illegible] in introducing the [illegible] upon the entrance of the [illegible] passage is shown in plate XXIV. fig 5 of the Atlas which [illegible] the [illegible] of the Kuttri, serves as a pattern for [illegible] on the [illegible] the Ranipoor. It consists of 2 [illegible] [illegible] at right angles to the [illegible] of the [illegible]. The [illegible] and well protected [illegible] the [illegible]. One of the passages [illegible] dimensions, but [illegible] [illegible] [illegible] [illegible] [illegible] adapted to [illegible] the accum[illegible] of the [illegible] to [illegible] [illegible] on the upper [illegible] of the [illegible] [illegible] deposits [illegible] the [illegible]. This [illegible] [illegible] passage delivers the water upon a thickly built and well protected series of [illegible] [illegible] with the [illegible] [illegible] [illegible] purpose of [illegible] of the water [illegible] of the water [illegible]
[illegible]

[illegible] with the masonry. The
[illegible] to
consist of [illegible] pieces and
[illegible] and
[illegible] material [illegible]
together by wooden [illegible],
this [illegible] by
[illegible] material [illegible]
[illegible] to a depth
of [illegible] feet. The [illegible]
[illegible] of the shaft passage itself
[illegible]
[illegible]
[illegible] shaft
[illegible] of 5 feet
[illegible] the [illegible] of the floor
of the shaft passage [illegible]
[illegible] machine.
The [illegible] is 100
[illegible]
[illegible]
[illegible] has been
[illegible] protected
[illegible]
[illegible]
of [illegible] in depth [illegible]
[illegible] together as [illegible] possible
[illegible]
[illegible] regulation
of water [illegible]
[illegible] works.

[illegible] the
water [illegible] the [illegible] of
the shaft passage, the works are
[illegible] condition.
Here, however, the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] on the
[illegible] of the
[illegible]
the water [illegible]
[illegible]

[illegible]

of the deep passage against the
breach walls, by [illegible] their own
progress. The deep [illegible]
[illegible]
[illegible]
[illegible] of the works [illegible] a [illegible]
distance, to oblige the water upon
the surface of the [illegible], and the
[illegible] it intended to protect the
down [illegible] of the building
from the action of the water by
[illegible] the deep pas-
sage [illegible]
The [illegible]
the [illegible] and the [illegible]
is [illegible] by [illegible]
[illegible] to [illegible]
the [illegible] at a point of the
[illegible] is [illegible]
[illegible] the [illegible]
[illegible]
the works [illegible] have [illegible] adopted
for both the Gallery and the [illegible]
deep passages [illegible] the
[illegible] upon them [illegible], the
extent to which they have been
carried in each will be seen by
reference to the plans. In the
latter, although the [illegible]
communicate [illegible] with the
deep passage [illegible]
[illegible] at the [illegible]
[illegible]
[illegible]
arising from local causes, and [illegible]
the [illegible] of the [illegible]
[illegible]
It [illegible]
by referring to the [illegible]
[illegible]
[illegible]
[illegible] upon the [illegible]
[illegible] by the interposition of

[illegible] of masonry, that [illegible]
[illegible] in a [illegible] [illegible] and
[illegible] [illegible] and to depress
the [illegible] of the [illegible] passage
to the lowest possible limits be
[illegible] the [illegible] should be below
the [illegible] of the supposed limit
[illegible] of the [illegible].

[illegible] have been [illegible] fully
[illegible] upon [illegible] the [illegible]
[illegible] [illegible] in the case of
the [illegible] (of the [illegible]
[illegible] [illegible]) [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] of the
[illegible] [illegible] [illegible].
[illegible] for a [illegible] to
boats along the [illegible]
[illegible] [illegible] height of
water equal to 10 feet, and that
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] of the passage [illegible]
[illegible] across the Canal. [illegible]
10 [illegible] 3 feet was [illegible]
[illegible] that [illegible]
[illegible] I had also to [illegible]
[illegible] the [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] different [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] the distance would be
[illegible] [illegible] [illegible], I
had [illegible] [illegible] to work
upon it.

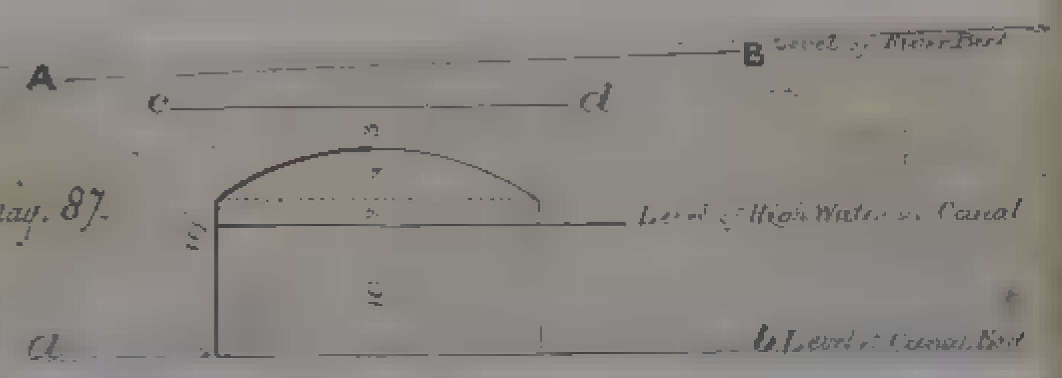
10 feet Deepest water
3 feet thickness of masonry for the [illegible]
6 feet for [illegible] for the passage of
boats and [illegible] [illegible] of
[illegible] floods.

giving a total of 19 feet in depth
the following Diagram will
illustrate [illegible] [illegible]

remaining

waterway.—

Diag. 87.



[illegible] we considered that 6 feet was an unnecessary height of headway, the 17 feet above. There was an indispensable and fixed measurement by which I was limited.—

In the case of the [illegible] supply passage which was built on the data of the natural current, it is sufficient that the lines A B and a b are separated by a depth of 22·445 feet, so that the crown c d of the supply passage is 3·445 below the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] occurrence of floods during the [illegible] that we have had the [illegible] [illegible] registers the fluctuations in the height of the river have been so great, that it is [illegible] to [illegible] what may be the result of the supply passage itself [illegible] at any rate the flood will reach the passage at the first instance on a [illegible] day [illegible] 3·445 feet of which it will have [illegible] [illegible] it [illegible] the [illegible] [illegible]. The [illegible] work is [illegible] to have [illegible] situated in this respect, but I shall reserve any remarks on that until hereafter.

[illegible] [illegible] [illegible] the [illegible] places on the level of the supply passage [illegible] of the [illegible] —

[illegible] from the
[illegible] of the [illegible]
[illegible] the [illegible] to the [illegible]
[illegible] of the [illegible]
[illegible] the [illegible] up [illegible]
[illegible]. It is clear that
[illegible] may have been [illegible]
[illegible] the [illegible]
[illegible] and, [illegible]
the [illegible] required to make
the [illegible] banks [illegible] the slope
of the country. In the case of
the [illegible]
[illegible], and [illegible] of the
[illegible] 907 [illegible] the [illegible]
[illegible] slope of
2513 [illegible] the [illegible]
a slope [illegible] the [illegible]
[illegible] to
the [illegible] 3 [illegible]
[illegible] It is
[illegible] that this slope
[illegible] by
the [illegible]
[illegible] as [illegible] of [illegible]
[illegible]
[illegible] the [illegible]
[illegible] by raising the
[illegible] a sufficient height
[illegible]
[illegible] that might be due
to the [illegible] slope [illegible]
[illegible]

[illegible]
[illegible]
[illegible] the [illegible] of the
[illegible] of the [illegible]
[illegible]
[illegible] brought
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]

[illegible] all the buildings [illegible] were made [illegible]

The bricks 12" × 6" × 2½" were burnt in the manufactories at the village of [illegible] in the same species of kiln as has been used at [illegible]. They are of the best description [illegible]

The quantity of materials which was expended on the [illegible] was as follows:–

Bricks — 12" × 6" × 2½"		6213753	
Do — 12" × 6" × 2"		1500	
Boulders		1467814	maunds
Stone Lime		300294	Cub feet
Soorkee		298395	do

[illegible] following ingredients

1 Part Stone Lime
1 – Soorkee –

with the most abundant [illegible] obtainable.

The rates at which the work was executed are given in the following table.

Total Content of Masonry	1636252 Cub feet			
Arch Masonry —	23	.	3	per 100 Cub feet
Brick – Edge do —	15	14	4	pr do
Plain — do —	15	11	..	pr do
Boulder — do —	10	8	10	pr do
Plaster —	5	8	3	per 100 Sq feet

[illegible]

At the Government well at a distance of 2050 feet to the west ward [illegible] water [illegible] at a depth of [illegible] feet from the [illegible].

No.	Names of [illegible]	Depth of [illegible]		Remarks
1	[illegible]	3	3	[illegible]
2	[illegible]	6		[illegible] 30 [illegible]
3	[illegible]	1	6	[illegible]
4	[illegible]	1	4	[illegible]
5	[illegible]		9	[illegible]
6	[illegible]	1	5	[illegible]
7	[illegible]		6	[illegible]
8	[illegible]	1	9	[illegible]
9	[illegible]	1	9	[illegible]
10	[illegible]	2		Do.
Total depth [illegible]		50		

[illegible] along [illegible] the width of that part of it which lies in the [illegible] of the Canal, is equal to about 13 [illegible] miles, the [illegible] of [illegible] of mountains, and the other half of a [illegible] level country, the latter on a very uniform slope towards the Canal. A map of the country lying between the foot of the Hills and the Canal with its surface marked by [illegible] lines denoting the relative [illegible] with reference to the flooring of the regulating bridge at [illegible] from the Zero from which all the Canal levels are counted will be found at Plate III. of the Atlas. —

The quantity of rain water that would fall upon a surface equal to the [illegible] allowing 12 inches in [illegible]

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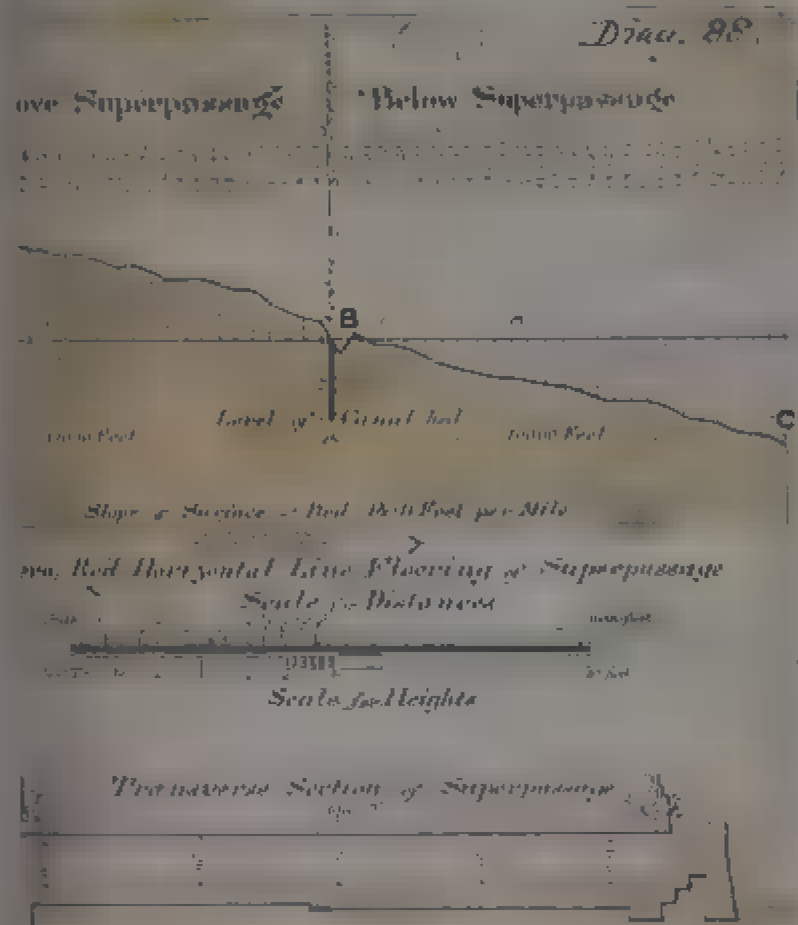
[illegible] would be [illegible] a maximum [illegible] The [illegible] of the superpassage [illegible] discharge may be estimated by the following table.

D	[illegible]	Velocity V	u	U	Area	[illegible]ue a[illegible] per second
1	11·879	5·127	7·546	2·703	196·167	1005·743
2	23·370	7·279	10·188	4·379	392·334	2855·799
3	34·932	8·907	12·137	5·677	588·501	5241·778
4	46·119	10·258	13·730	6·786	784·668	8049·123
5	57·098	11·431	15·104	7·758	980·835	11211·985
6	67·849	12·475	16·315	8·635	1177·002	14683·100
7	78·404	13·423	17·410	9·430	1373·169	18432·047
8	88·700	14·293	18·410	10·174	1569·330	22429·130
9	98·923	15·097	19·331	10·853	1765·503	26653·759
10	108·897	15·849	20·212	11·524	1961·670	31129·741

where the [illegible] depth of the water [illegible]

[illegible] a depth of water [illegible] would be [illegible]

By reference to [illegible] section which [illegible] of the [illegible] and [illegible] of the superpassage it will be seen that the [illegible] AB [illegible] an average of 15·86 [illegible] BC [illegible] 12·35 feet [illegible]



LEVEL OF THE [redacted] OF THE RANIPOOR RAC

Diag. LXXXVIII. 1853

(Dia[illegible] Diag. LXXXVIII [illegible])

? [illegible]

[illegible]te for the Printer

"Slope of Surface of Bed" to be under [illegible]w. "Centre of Superpassage" above the figures

distance of 1411 feet in length. It is upon the higher slope that the bulk of the [illegible] above given [illegible] calculated, and it is upon the diminution of the slope from B to C or from the flowing of the sluff passage downwards, that dependence [illegible] for the establishment of deposits in the region of B or both on and in the neighbourhood of the openings of the sluff passage.

The [illegible] works were made under the superintendence of [illegible] by [illegible] Assistant Engineer, whose duties in arranging the Tunnel, and in counteracting the effects upon the delivery during the period that the works were going, by means of [illegible] the [illegible] of [illegible] accumulation.

The Outlet Sluff passage and the works connected with it

This work is similar in design to that at [illegible] with the exception of the [illegible] of the [illegible] There are [illegible] of equal dimensions [illegible] feet in width [illegible] the [illegible] and [illegible] the [illegible] tipped [illegible] works, and the breadth of sluff passage being 296 [illegible] is 196.

[illegible] by the [illegible] that which [illegible] the [illegible] [illegible] the [illegible] the [illegible] [illegible]

[illegible]

[illegible], by the [illegible] watershed on the South by the [illegible], on the East by the water shed of the [illegible] [illegible], and on the West by that of the [illegible] [illegible] [illegible] as [illegible] on the [illegible] [illegible] (Plate III of this Atlas) will demonstrate [illegible] the connection or [illegible] connection, [illegible] that exists between these two lines of drainage, the [illegible] [illegible] [illegible], but [illegible] the [illegible] [illegible] [illegible] on the [illegible] of the [illegible], and in that of the [illegible], as [illegible] [illegible] the [illegible] of the [illegible] basin, the natural [illegible] of the [illegible] are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] features of the [illegible] [illegible] [illegible] [illegible] east to west [illegible] to the [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] the [illegible] basins [illegible] [illegible] [illegible] [illegible] in the upper [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible], it would appear that the basins of the [illegible] and [illegible] are actually connected and that [illegible] [illegible] [illegible] [illegible] the whole of the [illegible] that [illegible] [illegible] the [illegible] and [illegible] [illegible] down the [illegible], might [illegible] [illegible] [illegible] into the [illegible] The [illegible] offered by this [illegible] [illegible] for [illegible] the [illegible] of the [illegible] [illegible] has been [illegible] [illegible] [illegible] it is by no means impossible that

but it may be convenient here-after to take advantage of the facilities [illegible] by the Pulti deep passage, [illegible] the [illegible] supply [illegible] the [illegible] Lane. This change [illegible] would require careful management, so as to prevent the water from coming [illegible] contact with the Canal on that part of its [illegible] or the west of the [illegible] [illegible], to [illegible] [illegible] the Canal [illegible], but at the same time it is feasible, and may be considered as a resource in the event of the Pulti deep passage being [illegible].

The [illegible] of the [illegible] [illegible] within the boundaries [illegible] [illegible], designated [illegible] which have been [illegible], [illegible] [illegible]. One of which is connected with the [illegible], and with a [illegible] [illegible] [illegible] established may be considered as subordinate to [illegible] [illegible] the East of the [illegible] of the [illegible] the [illegible] [illegible] connected with the [illegible] [illegible] of [illegible] [illegible] with sediment, the latter [illegible] dis-[illegible] [illegible], [illegible] [illegible] the [illegible] [illegible].

The [illegible] [illegible] [illegible]

[illegible]

may be termed the Pattenwar basin, the extent of which is equal to 11 square miles, but which during very high floods is supposed to be liable to an accession of water from the neighbouring torrents, is provided with an Inlet of 150 feet in width situated on the right bank of the Canal; the flood water therefore from this source will pass down the Canal Channel and obtain an escape at the Puttunoo Dam. It has been provided also that the floods in extraordinary cases should have the means of escape over the country situated to the South of and opposite to the Inlet, by openings ~~left~~ for their passage through the left Embankments of the main Canal channel. — The actual area of the catchment basin [illegible] of which the [illegible] may be [illegible] [illegible] 30 [illegible] [illegible]

[illegible] the [illegible] at the point of intersection with the Canal, [illegible]

[illegible]

[illegible] between the channels [illegible] and [illegible]

[illegible] the difference is greater [illegible] which [illegible]

[illegible] even more serious [illegible] the more necessity [illegible]

[illegible] 3 [illegible]

[illegible] Plate XXIV [illegible]

[illegible] the natural position [illegible]

[illegible] the waters; [illegible] that the work might be executed without hindrance during the [illegible] floods; [illegible] that the [illegible] adjusting [illegible] made from the [illegible] to the [illegible] of the [illegible] might [illegible]

81 – G – Vol ii
[illegible] part iii

Note for the Printer.

A. Depth to which springs were reached by [illegible]

B. Depth to which springs were reached [illegible] in this diag. [illegible] the [illegible] of the Overfall

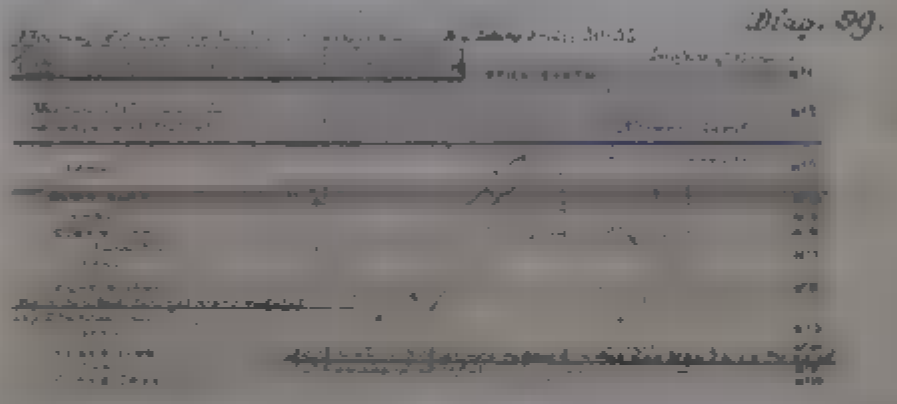
The text untouched —

~~It~~ was possible to ~~[illegible]~~. The value in point of economy of the latter season will be understood by referring to the following diagram which shews the nature of the soil through which the excavation of the Puttri superpassage was carried, and the depth at which spring water was found.

Diagram

Section shewing the different strata of Earth at the Over Fall of the Puttri Superpassage

Diag. 89.



From it will be seen from the above Diag. and that the actual depth of digging from the surface of the country to the foundation bed on the right flank was 6·8 feet, to gain the lower bed was 1[illegible]·6 feet. In case the bed on which the culvert and foundation rested, the depth to be dug was 8·8 feet, that of the floorings on the greater part of their extent was 23·6 on the lesser part 22·7; the last foundations had to be sunk to a depth of 3[illegible] feet from the surface of the country, below which there was spring water at a depth of 23 feet.

Plate XXIV. of the Atlas shews an outline of the Floods of 1850 and their effects upon the Puttri works, which previous to the rainy season of that year had been commenced, by the [illegible]

ment of Embankments for the protection of the works, and by the formation of a channel 300 feet in width to which it was intended to limit the Torrent — The different works that were constructed at this period are shewn in the plan above alluded to —

The effects during this season appear in their action to have been quite independent of any of our proceedings; the current in an early part of its course and high up on the bed of the river spread over the Country taking direction to the East, and to the point of the Canal where the Selimpore Inlet is now built a considerable portion of the current in fact, passed into the portion

of land which has been designated the Selimpore basin, and the [illegible] bank which [illegible] further [illegible] a good deal of the [illegible] spreading over the country [illegible]; the [illegible] was [illegible] the [illegible] the 300 feet Opening [illegible] through [illegible] the [illegible] [illegible] increased [illegible] its [illegible] deep passage without [illegible] actual damage — On the 20th of [illegible] 18[illegible] [illegible] [illegible] the ~~[illegible]~~ the [illegible] works, a flood [illegible] occurred during the night [illegible] away the left flank of the [illegible], and [illegible] the channel [illegible].

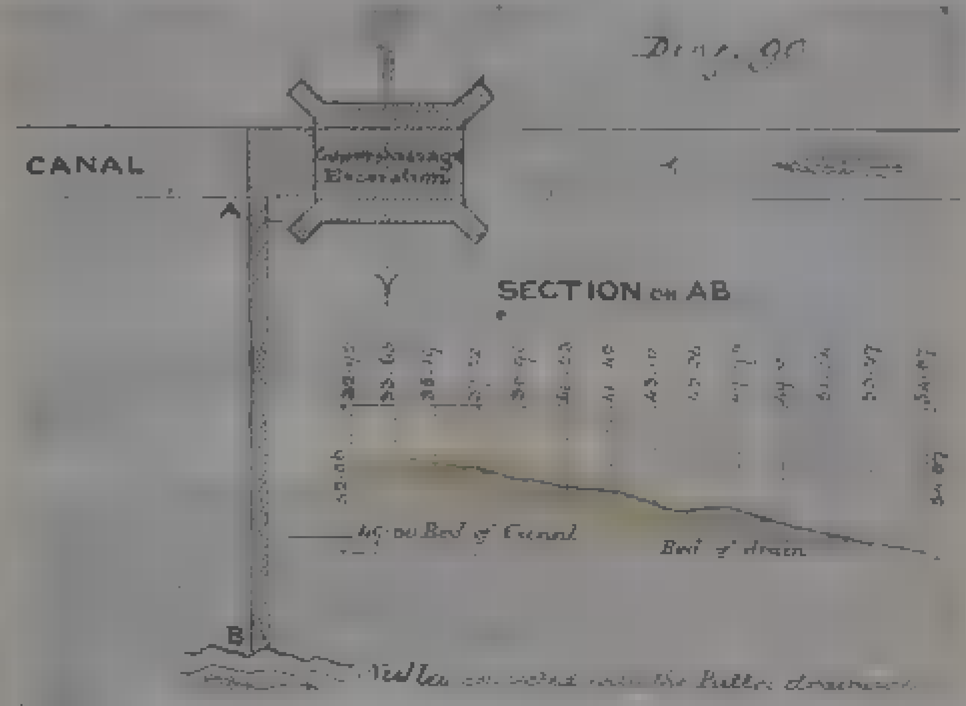
of 15 feet. The general effect of the passage of the current through the opening during this period was unavoidably to deepen the channel where it was most constricted, and the extent to which this took place is shown in Fig 2 of the plate above opposite. During the rainy seasons 1851, 1852 and 1853, the current was still running rather [illegible] passed off in the diminished stream. It has again been thought advisable for the security of the deep passage during its construction to leave the breaches open, and by these means to give relief to the passage of the water at points distant from the masonry works. In this manner the floods for 3 years have gone by without producing any damage. The range of the opening has during this period, although passing all the great volumes of water, experienced a variety of changes, and at the time that I am now writing (1854) is now [illegible] the bed being [illegible] the same depth as it was previously to the rains of 1850.

The greatest may be said (ordinary) difficulties that the Engineer in charge had to contend with in laying in the Masonry work, must under the above named circumstances be evident. He however succeeded in reducing the [illegible] water level to a depth of 18.25 [illegible] from the deep part of the bottom, and in laying the works [illegible] of the pending foundation [illegible]

in order with little or no im-
-pediments to be quite. The
land foundations which consisted
of blocks of masonry were under-
-sunk to a depth of 20 feet, and
those portions of the curtain and
base walls below the surface.
Springs here were laid in by
the use of "Dalis," or drops by
which the water was [illegible] to be
removed from the excavations. –

The situation of the Canal
(crossing at right angles a country
lying on a "slope" slope) was par-
-ticularly favourable to the operations
for drainage, and this was taken
advantage of in the most con-
-venient way by making a
cut from the Canal bed to the
bottom of the slope, and as the
spring water passed away, grad-
-ually deepening both the excav-
-ations for the works and ~~[illegible]~~ for
the drainage until the water was
reduced to a minimum. The
plan adopted ~~[illegible]~~ is
shown in the following diagram,
accompanied by a profile of
the country on which the drain
marked AB was excavated.

Diag. 90



When this portion was completed, and
the drain is completed, [illegible]
[illegible] that during the [illegible]

Note to the Printer

The words "Section on A.B" and the [illegible] of figures to be set up and the [illegible] and the words "Bed of drain" [illegible] the words "Nullah connected with" [illegible] the block

the building operations any further difficulty existed than in the maintenance of the drain as cut at a [illegible] and [illegible] line. This as might be expected was, at the lower levels subject to the falling in of earth from its sides and to deposits of sand and mud from the action of springs and running. There was a constant necessity for working parties being employed upon it, but the free passage of the springs water to which it secured, rendered the progress of building comparatively easy.

The soil upon which the masonry rests is far from being a satisfactory one, the drawbacks already stated of its being ~~[illegible]~~ saturated with springs, while the nature of the soil itself in which the springs act, being composed of a mixture of sand and clay, is an evil of great magnitude. I have trusted however to the massiveness of proportions of the foundation, and to the extensive surface which they cover, equal in area to 331½ × 285 or 94477½ square feet as a protection against any serious disarrangement of the superstructure by after settlements. The result however has not proved so satisfactory as would have been wished, the line of blocks at the [illegible] has led to a slight settlement a [illegible] showing [illegible] the [illegible] like form which is given to the soil in the progress of [illegible], and consequently [illegible] probability [illegible] that these [illegible]

the

to move after the superincumbent weight was placed upon them. The flooring of the left chamber, or of that ~~which is~~ devoted to Lock purposes which from motives of economy was reduced in thickness to 2½ feet has also slightly settled. These defects, however, will not I imagine act prejudicially, nor will the settlement proceed further than it has already done.

The building is constructed entirely of brick (12" x 6" x 2½" in cubic measurement, burned in the Selimbroor manufactories) and boulders, the latter being used in all the massive parts of the foundation, the former in the outer surface (18 inches thick) of the cases and floorings, and in the superstructure. The centerings for the arches were formed of earth well watered, on the native plan, which has as a general rule been adopted throughout these works. With certain disadvantages which are noted in the Chapter on Bridges, this species of centering has the great recommendation of cheapness, added to a facility of adaptation to the purpose, which no other species of centering offers. The boulders, with which the foundations are built, and which are so extensively used in the protective works appended to the superpassage, were collected at the mouths of the passes into the Sewaliks and from the bed of the Sonasi River, from whence

[illegible]

Brick	12" x 6 x 2½"	9411011	
Do	English machine	366144	
Boulders		1404262	Maund
[illegible]		2224.8	Cubic feet
Stone [illegible]		285757	"
[illegible]		408465	"
[illegible]		80479	"

[illegible]

Boulder Masonry	1 [illegible] 1 [illegible] 1 [illegible]
Brick masonry	1 [illegible] 2 [illegible] [illegible]
Protection works 10 [illegible] 10 [illegible] 10 [illegible] 5 [illegible] 5 [illegible]	3 [illegible] 2 [illegible] The whole [illegible] [illegible] 27 [illegible] [illegible]

[illegible]

Total Cubic Contents of Masonry	2243571 Cubic feet
Rec. Masonry	23 15 1 per 100 c. ft.
Brick on Edge "	19 1 2 per "
Plain " "	16 13 8 per "
Plaster	2 3 6 per 100 sq ft

[illegible] Made [illegible] Man [illegible]

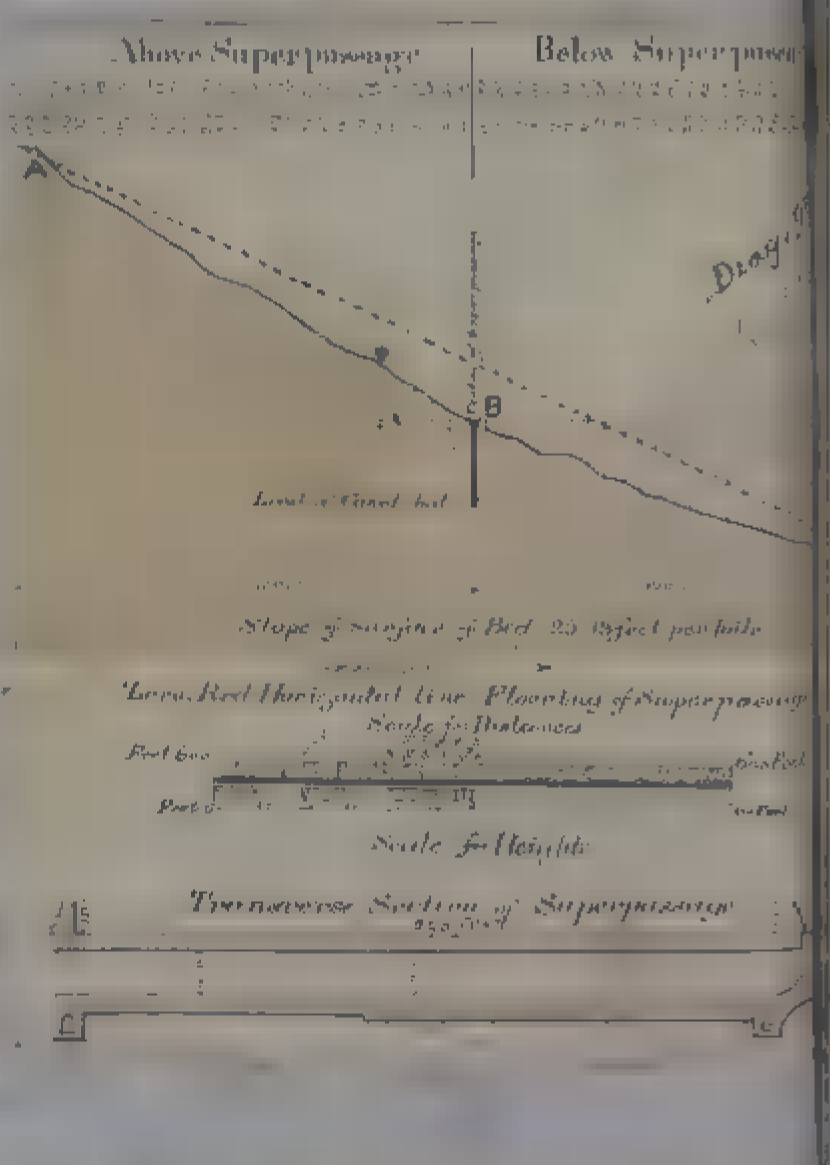
[illegible]

[illegible] 25 13 [illegible]

[illegible]					[illegible]	[illegible]
D	R	V	H	U	[illegible]	[illegible]
1	11.94[illegible]	7.15[illegible]	10.0[illegible]	4.2[illegible]	2[illegible]6	2116.992
2	22.65[illegible]	10.1[illegible]	13.631	6.713	[illegible]	6021.324
3	33.[illegible]	12.[illegible]	16.314	8.613	888	11069.305
4	46.757	14.381	18.3[illegible]	10.[illegible]	1134	17037.104
5	58.039	16.052	20.411	11.[illegible]	1480	23756.960
6	69.[illegible]	17.3[illegible]	22.118	13.[illegible]	1[illegible]	31154.[illegible]
7	80.[illegible]	18.908	23.649	14.[illegible]	2[illegible]	39177.376
8	91.017	20.11[illegible]	25.03[illegible]	15.196	2308	47627.[illegible]
9	101.809	21.331	26.[illegible]	16.29[illegible]	2[illegible]	56835.184
10	112.4[illegible]	[illegible]	[illegible]	17.133	[illegible]	65963.[illegible]

[illegible] AB [illegible] 31 [illegible] BC [illegible] 1533 [illegible]

Br 2600
B. 58



LEVEL OF THE BED OF THE PUTTRINUDDI

Diag: XCI. 1853

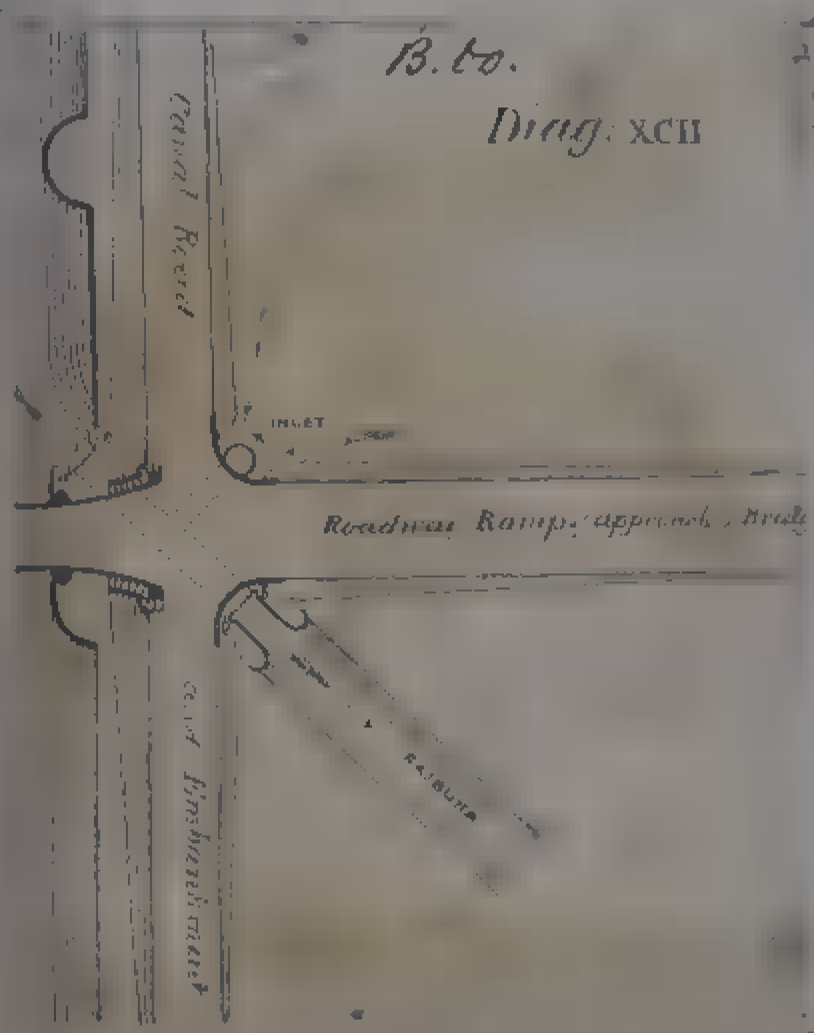
[illegible] AC [illegible]

B.

V.

[illegible]

[illegible] Diagram XCII



[illegible] radiuses of [illegible] rounded, and the ramp [illegible] constructed [illegible]

[illegible] the [illegible] [illegible] [illegible] [illegible] with the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the top with [illegible] at × [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] Kuchha(?) (as shown in the former section.) The surface [illegible] Country to the [illegible] of × is low & [illegible] with [illegible] arranged in the side of the [illegible] that during periods of low [illegible] the Canal Channel, the [illegible] be turned to account —

It will be observed [illegible] Inlet Channel opens into [illegible] the Rajbaha, by which it [illegible] naturally escape, without [illegible] at all with the supply in [illegible]

[illegible] [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] on the down [illegible] [illegible] at b.b. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] passing from the [illegible] by closing the [illegible] at b.b. and leaving [illegible] the [illegible]. This [illegible] [illegible] [illegible] [illegible] establishment [illegible] [illegible] [illegible] [illegible] water [illegible] down to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] properly [illegible] have always been highly appreciated by the natives [illegible] — [illegible]

[illegible]

putting it in practice

CHAPTER. II

[illegible]

[illegible]

I. [illegible]
II. [illegible]
III. [illegible]
IV [illegible]

[illegible]

[illegible]

1. [illegible]

[illegible]

A [illegible]

B [illegible]

[illegible]

[illegible]

A [illegible]

B. [illegible]

C. [illegible]

D. [illegible]

A [illegible] 1846. [illegible] £100? [illegible] predominate [illegible] MX? [illegible]

[illegible]

2 Parts St Earth Lime
1 " Sorkee

[illegible]

1st Coat { 1½ Parts Stone Lime / 1 " Soorkee }
2d " { 2 Parts Stone Lime / 1 " Soorkee }
3d " { 7 Parts Fresh White Stone Lime / 1 " Soorkee }

[illegible]

	Contents of Work		Materials		
	[illegible] masonry	[illegible]	Bricks [illegible]	Earth Lime	Soorkee
Masonry	136046	33568	1020345	45349	22671
Arch Masonry		14 8 4	p. 100 Cubic ft		
Plain "		12 1 5	p. "		
Plastering		4 4 9½	p. 100 [illegible]		

Masonry	20262	5	10
Protection work	6078	3	2
Earthwork	1531	1	9
Plastering	1548	15	6
Metalling	350	4	-
Probable cost of work yet to be done	4875	-	-
Total Cost Rs.	34646	14	3

B.

Contingent Works		Materials				
[illegible] of Masonry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			mas		mas	mas
102817	48552	282204	110132	191	28620	

[illegible] Masonry	16	per 100 Cub. [illegible]
[illegible] Do	13 7	do
Plastering	2 ½	per 100 Square feet
[illegible]	2	do
[illegible]	15	each
[illegible]	30	do

[illegible]

Masonry	14813 15 8
Plastering	1192 12 3
[illegible]	510 . .
[illegible]	1553 14 5
[illegible]	1050 . .
[illegible]	2000 . .
Total Contingent [illegible]	20075 10 4

[illegible]

C

[illegible]

Powder and Carriages

[illegible]

[illegible]

[illegible] 20th [illegible]

[illegible]

Total	[illegible]	45508	[illegible]
Rates	[illegible]	16	per 100 [illegible]
	[illegible]	14 14 [illegible]	[illegible]
	[illegible]	[illegible] 3 3	per 100 [illegible]
	[illegible]	[illegible]	[illegible]
	Bell [illegible]	15	[illegible]
	[illegible]	30	[illegible]

[illegible]

Mason[illegible]	11378 . 1 3
Plaster[illegible]	1008 .. 9
Metal [illegible] & appurtenances	514 12 9
[illegible]	2727 .. ..
Wood [illegible]	1125 .. ..
[illegible]	1500
Total Compys Rupees	18252 14 9

[illegible]

D. [illegible]

[illegible]

[illegible]

[illegible] 12" x 6" x 3".

[illegible]

1 part of [illegible] Lime to 1/20th of White stone Lime. –

[illegible]

[illegible]

		Masonry	Plaster	Bricks	[illegible]	[illegible]	[illegible]
Mason	[illegible]	139 926	43772	2240000	[illegible]	105	36137

Rates	Arch masonry	15 . . per 100 [illegible]
	Other do	12 . 10 . per do
	Plastering	1 13 6 per 100 square feet
	[illegible]	1 [illegible]
	Brick [illegible]	12 [illegible]
	[illegible]	[illegible]

[illegible]

Masonry work	14554 7 6
Plastering	807 1 7
[illegible] & approaches &c	2138 9 [illegible]
Protection	2074 12 10
Woodwork	460 . .
[illegible]	[illegible]
Total Cost Rupees	**[illegible]**

[illegible]

case at this particular point [illegible]
[illegible] [illegible] [illegible] independent
[illegible] 2 miles north of the
Reservation [illegible] [illegible] provided for
the additional [illegible] of the
[illegible] [illegible] [illegible] Avenue,
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] Commissioner
I cannot [illegible] [illegible]
[illegible] [illegible] either to the
[illegible] or to the Community
[illegible] [illegible] improvements which
[illegible] [illegible] adopted in this case
~~[illegible]~~

Speaking of the [illegible],
[illegible] the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] attention
to the [illegible] in the [illegible] [illegible]
[illegible]. I am [illegible] that the
[illegible] of the [illegible] [illegible]
[illegible] [illegible] in [illegible] substantial
[illegible] [illegible] [illegible]
to the [illegible] or to the community,
[illegible] [illegible] bridges and [illegible] of
[illegible] [illegible], [illegible] the roads themselves
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] of [illegible],
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] of
15,000 [illegible], [illegible] [illegible]
of [illegible] [illegible] [illegible], [illegible]
[illegible] [illegible] [illegible] must
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible].
At any rate [illegible] as [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible], with
[illegible] [illegible] [illegible] ~~[illegible]~~
[illegible] [illegible] [illegible] by
[illegible] that [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]

is an inconvenient one) altho' in the Question of the Ganga 2nd 13 ridges [illegible] consideration.

In the [illegible] of the cases where Regulating Bridges are in contact with high roads the absence of [illegible] throughout renders them [illegible] inconvenient.

The above remarks will shew that doubts have existed in Government as to the [illegible] of [illegible] the body to the double purpose to which they have been [illegible], and there can be no question that such [illegible] had very great weight in influencing the determination.

In [illegible] this portion of the chapter, I may remark to point out the terms ~~[illegible]~~ I have, with regard to the Establishment which ought to be maintained for the working of the Regulators at the heads of Branches. I am inclined to place these on the same footing as that of the Regulators on the [illegible] as [illegible] under Section I, giving to [illegible] the same duties, and making them responsible to the main [illegible] of the [illegible] working [illegible] within a distance of [illegible]. [illegible] view of the Question, and [illegible] in mind that the maximum number of gates at any one head, which may be required to be worked at one time, are those over the [illegible], I would [illegible] the Establishment thus:

1 Wattoukh [illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 Bo[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]
3 [illegible]	[illegible]	[illegible]	3	3	[illegible]	[illegible]	[illegible]
4 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

the provinces in [illegible] to investigate [illegible] just cause a [illegible] is desirable for the [illegible] [illegible] as well as for maintain[illegible] [illegible] in [illegible] [illegible] [illegible] would have a [illegible], and to [illegible] the [illegible] and [illegible] with the same duties as are laid down for the [illegible] attached to the [illegible] and [illegible]; and as at these [illegible] the [illegible] Rules and Regulations [illegible] [illegible] and [illegible] be hung up in the [illegible] buildings and [illegible] stations.

III. Couriers.—

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] classes [illegible] [illegible] [illegible] [illegible] [illegible] that the [illegible] at [illegible] and [illegible] [illegible] [illegible] [illegible] capable [illegible] [illegible], [illegible] they [illegible] used for this purpose [illegible] [illegible] distinctive [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] passing [illegible] the [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] requisition.

St.

It is on [illegible] [illegible] of the Country and upon the localities [illegible] [illegible] the [illegible] of the [illegible], that the [illegible] which are placed upon the [illegible] began to demand [illegible]. It [illegible] be understood that [illegible], [illegible] in their relation to local Irrigation, and [illegible] [illegible] in drawing and [illegible] out the water from the main [illegible], the equilibrium which should exist between the supply and the capacity of the channel at given points must be [illegible]. For instance, [illegible] the construction [illegible] made for the purposes of Irrigation [illegible] (a [illegible] 86 miles) equal to 8 feet [illegible], [illegible] the [illegible] of the channel is [illegible] ~~[illegible]~~ It is probably [illegible] that on such a long line, extending along the foot of the mountains where the climate is moist, to regions where [illegible], the climate is [illegible], the demands upon the supply must not only vary with [illegible] to climate and soil, but must be perpetually dependent on local rainfall, the extent of which in these provinces is very remarkable. These irregularities, necessarily attendant on local causes must be met by efficient remedies, and in this case by providing outlets at stated distances along the line of channel, so that in the event of a super-abundant supply, which is observed by a water gauge [illegible]

Ch. II.
3 – 9
= Ch. II

for this purpose the extra water may be passed off and allowed to escape into side channels. I have before alluded to the Raybuha Heads and their channels, as the safety valves for maintaining an equilibrium under excess of water, they will undoubtedly act in this respect most beneficially. The works, however, which I am now describing are specifically for the purpose of regulating the channel supply, and for maintaining it at such a depth as may be most convenient to the works, or most useful to the cultivators. In designing these works I have laid down the following rules for my guidance, and although from local causes they have not always been strictly adhered to, they have been followed to an extent sufficient to meet the purposes which are contemplated.

1st With reference to position I have limited the distance between the Escapes to 20 miles considering that by adapting their capacity for outlet to the volume of water contained in the 20 miles of channel to which they are intended to provide the means of escape* the facilities for regulation will be complete.

2nd On the Sandy tracts which constitute the greater region lying above the Ganges and West Kali Nuddee to multiply the number of escapes rather than to increase their waterway, to encounter the difficulties of contending with large volumes of water collected within them in masses, and to facilitate

and

and into the drainage line [illegible] escape would be [illegible] of the means as well as by artificial protective expedients.—

3rd To fix the sites of all escapes in such a position that there may be a plunge into the bed of the drainage channel, and that the high water mark of the latter may in no case interfere with the free discharge of the water from the Canal.—

4th To make the Escape buildings a component part of other works, or when this may not be practicable, to place them in near proximity to Bridges and buildings, that they may be easily accessible and properly looked after.

5th Independently of [illegible] [illegible] [illegible] [illegible] escape channel [illegible] [illegible] with [illegible] depth of 12 feet [illegible] the [illegible] at the tail of the escape [illegible] a depth of [illegible] equal to [illegible] [illegible] the escape [illegible] [illegible] works in masonry, adapted to the particular circumstances under which the Escape Channel is situated.—

From Roorkee [illegible] downwards the sites of escapes for the relief of the [illegible] Channel have been determined on the above principles, unless there have been reasons which will be fully explained, for their having been departed from.

G

It will be advisable for the sake of distinctness to divide the Escapes under different heads

A Those on the Main Trunk between Roorkee and Nanoo

B On the Cawnpore Terminal line

C On the Etawah do

Commencing with A we have on the Main Trunk

1. The Khutowli Escape 62 miles
2. Mahomedpoor do 69 do
3. Jannikhoord do 87 do
4. Moondakhera do 141 do
5. Kasimpoor do 166 do

These different works situated at distances from the Myapoor Regulator as given above.

[illegible] the three leading items viz. the Escapes at Khutowli, Mahomedpoor and Jannikhoord, are [illegible] of the channel at points where, from the large volume of water that it has to carry, [illegible] of the soil through which it is conducted, most [illegible] care is required. These Escapes may be considered under the 1st head [illegible] to guidance as two outlets divided into three separate lines. The width of waterway in aggregate is equal to 180 feet, and as separate works, they provide a discharge of 66 feet in width, each work consists of 11 bays, [illegible] of 6 feet in width each, and they [illegible] their water into the valley of the East Kali Nuddee under circumstances previously provided with reference to the [illegible] of channel, although from the sandy nature of the soil through which the bed is excavated, and

[illegible] be [illegible]
[illegible] by masonry [illegible]
~~[illegible]~~ the completion of [illegible]
Group [illegible]
[illegible]

These [illegible] 3 Groups [illegible] procedure [illegible] first [illegible]

No. 1. [illegible] Group

This building is situated [illegible] Rentou [illegible] road between [illegible] The area of [illegible] 3 Groups [illegible] 550 feet.

[illegible] 60 [illegible] mins. [illegible]

[illegible] Diag. XCIII)

[illegible]
[illegible] Hall

each [illegible] is 1921 feet one length of 2000 feet & 3 [illegible] to 190 feet, the total fall [illegible] being [illegible] have completed [illegible] with [illegible] [illegible] with the [illegible] due to [illegible] disposing of the superfluous fall would have been [illegible] impossible to [illegible] an undertaking demanding [illegible] it would not occupy the attention of [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible] to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] was [illegible] [illegible] [illegible] [illegible] [illegible] and the [illegible] double [illegible] [illegible] [illegible] for the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible], until the [illegible] [illegible] the [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] must [illegible] [illegible] [illegible] [illegible] the character [illegible].

[illegible] [illegible] [illegible]

the excavations [illegible] made [illegible]
slope of 1½ foot per [illegible], to where
the bed level struck upon the
slope of the valley; the above
slope was given to the heading
while its course fully, or up to
a point where the Channel is
crossed by the main Right Bay
line, to which a bridge of cross
communication is attached; from
this point the excavation was
carried on a dead level, by which
1½ foot in depth per mile was lost
[illegible] attached to the Regulator
[illegible] at [illegible] side
on the [illegible] of [illegible]
[illegible] depth, [illegible] in the [illegible]
[illegible]
depression, [illegible]
[illegible]
It will be understood that by
the above arrangement, out of
the total fall of 22½ feet from
the [illegible] head to that of the
[illegible]
[illegible] fall to the [illegible]
[illegible] head, 1½ foot in the slope
[illegible] and 8
feet in the [illegible], or
a total of 10½ feet; the remaining
slope having to be regulated
by an amount of masonry
[illegible] equal to 12 and the
balance being disposed of in
the slope of the [illegible]
[illegible] the [illegible] of the
[illegible]
the slopes upon which it is our
intention to regulate the rest
of the [illegible] channel, it is
obvious that the [illegible]
determining the proper position
in which, when [illegible]
[illegible] excavations, the

addition of masonry dams [illegible] will have to be built, the [illegible] [illegible] selected in the efforts material sufficient to execute the work with the greatest prompt[illegible] [illegible], so as to produce all [illegible] of the works which are situated in the reaching [illegible].

Where [illegible] the [illegible] when the precise [illegible] with the falls may be built hereafter [illegible] as great a distance between [illegible] as possible, the most economical material to use in the construction of these works will be masonry; by building them of the best type [illegible] works in the first instance, repair will be done hereafter, or their position [illegible] altogether. [illegible] [illegible] works [illegible] [illegible] will [illegible] [illegible] to [illegible] than would otherwise take place. [illegible] doubtful [illegible] the necessity of [illegible] [illegible] this [illegible] with by the [illegible] Officer and the [illegible] of the works.

[illegible] distribution of proposed works on the [illegible] with the necessary data on which they [illegible] arranged, may be [illegible].

[illegible]	[illegible]	30000 [illegible]
[illegible] canal [illegible] of [illegible]		29·21 [illegible]
[illegible] at 1·5 [illegible]	5·68	
[illegible] Slope of [illegible]	1·00	6·68
Balance [illegible] disposal [illegible]		22·53 [illegible]
[illegible]	3·0	
[illegible] intermediate [illegible] the [illegible] of [illegible]	15·0	
		23·00

It is desirable that the masonry dams should be placed at as great a distance from each other as possible, so as to prevent the accumulation of velocity in the [illegible], and to secure this, the above rule of placing the [illegible] distance [illegible] the [illegible], in practice [illegible] the [illegible] in all cases [illegible] both [illegible] so that [illegible] on the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] made.

The total [illegible] [illegible] [illegible] [illegible] [illegible] 2045.83 at a [illegible] equal to [illegible] 1.10.56 per 1000 cubic feet.

The Training [illegible] [illegible] of 10 [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] is equal to 6 [illegible] feet, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ([illegible] [illegible] [illegible]) [illegible] [illegible] the [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] by masonry [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] of the [illegible] [illegible] the [illegible] and [illegible] [illegible] [illegible] [illegible]

[illegible]

The arrangements of the [illegible] [illegible] Canal Embankments at [illegible], and the elevation of the upper [illegible] 6.0 feet above the Canal bed, the difficulties of opening and shutting the sluices has been [illegible] by a [illegible] of buildings, [illegible] the [illegible] and [illegible] as a Bridge [illegible], without interrupt[illegible] the [illegible] communication on the [illegible] supports [illegible], [illegible] upright timbers placed in the [illegible], but also as supports to the roof [illegible] great additional [illegible] to the building. It will [illegible] the plan Plate XXXVII that [illegible] attached [illegible] an [illegible], by which the whole [illegible] by the gate [illegible] through the [illegible] of the [illegible], raised as high as the roof; the [illegible] throughout [illegible] protection from the weather, [illegible] causes, it is hoped that the [illegible] in any [illegible].

The work is built with a [illegible] of [illegible] new brick, with [illegible] consisting of the following [illegible]

1 Part of Earth Lime
1 " [illegible]

The total quantity of materials used is as under:

4336 Bricks [illegible] sizes
192.83 Cubic Feet of [illegible] (Earth)
9641 " [illegible]

[illegible] the rates at which the work was executed were as follows

Masonry	Cu. ft 12.7.11 pr 100 Cub. feet
Plaster	2.3.7 pr 100 sup. feet

This ~~[illegible]~~ Escape was begun by Lieut. [illegible] of the Engineers, and completed by Mr. [illegible], under whom the adjustment of the machinery has been managed. The total cost was, excluding Regulating apparatus, Co.'s Rs 1178.2.4

No. 2 Mahomed Aboo's Escape

The [illegible] of this work with the exception of the [illegible] [illegible] accommodation for the [illegible] and the superstructure appended thereto, is the same as at [illegible] [illegible] [illegible] 13 feet in width [illegible] [illegible] from [illegible] to the soffit of the arch. The sluice gates [illegible] of the same description as those at [illegible] are worked by windlasses resting on the plank [illegible] commonly used on the Canal [illegible] in these Provinces. [illegible] are protected by a 2nd Class Bridge which is in close proximity to the work.

The site of Mahomed Aboo's Escape is on the right bank of the Canal between the 6th and 7th miles of its course from the [illegible] Regulator. It is the most isolated situated of the works of the Canal [illegible] being separated by a considerable distance from villages or

[illegible]

cross communication. [illegible] on the opposite side, it is bounded to that upon [illegible] the high road runs, access to it can only be gained by crossing the Canal, either at the [illegible] or at the Alameda Bridge, from the former it is 1065 feet distant, and from the latter 1760 feet. It would be desirable, perhaps, to open a lane and [illegible] road along the right bank of the canal as well as the [illegible] left, between [illegible] Alameda Falls and the Alameda Bridge, by which means of access would be required to [illegible] Avos [illegible], [illegible] [illegible] communication with this [illegible] which is now [illegible] [illegible], would be [illegible] [illegible] perfectly facilitated.

[illegible] lake not as its name indicates is a portion of the [illegible] [illegible] [illegible] Alameda. As will be seen by the plan on the following [illegible] we have taken possession of the [illegible] of those [illegible] which appear to have been [illegible] used as [illegible] of the [illegible]. [illegible] [illegible] it [illegible] [illegible] [illegible] by a [illegible] direction towards the [illegible], [illegible] it joins [illegible] [illegible].

(See Drawing No. XCIV)

[illegible] [illegible] designs [illegible] [illegible] [illegible] required for [illegible]

this use of Drafts will be explained by the Drawing.

Distance from the Canal Channel to mean - feet the lowest water [illegible]		7·311
Other fall from head of Canal to level of River		2·3 [illegible] ft
Required Slope		
From the level [illegible]	1·00	
Channel Slope in 7 miles 1 1/2 feet per mile	10·50	11·5
[illegible] Supply [illegible]		12·43 ft

To which it would be sufficient to give 2 descents of 6 feet each, ~~which would~~ admitting of the use of [illegible] communication, [illegible] which the [illegible] of [illegible] Rajbaha would [illegible]. I have [illegible] the [illegible] Khutowli Drafts, [illegible] [illegible] the depth [illegible] [illegible] with [illegible] of it. I have designed the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with a [illegible] [illegible] this [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] with the [illegible] of [illegible] [illegible] [illegible] [illegible] connected with a deep passage channel for the Rajbaha [illegible] these [illegible] of certain localities, where the depth is very [illegible] and [illegible] the bed of the Rajbaha [illegible] By [illegible] the [illegible] [illegible] and [illegible] the [illegible] [illegible] [illegible] to 3 feet, [illegible] [illegible] to the [illegible] of that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

the height of the [illegible] and is adapted to the section of the excavated channel. It would in no case reduce the waterway of the bridges [illegible] the width, as [illegible] frequently of the surplus water from the land [illegible] will readily pass through it [illegible] a tract without [illegible] in its course a considerable quantity of country drainage.

The [illegible] upon [illegible] [illegible] channel had been excavated, [illegible] as that proposed at Kaiapoi [illegible] has been excavated to a depth of [illegible] from which point it is [illegible], nature being allowed to work her own progress [illegible] retrogression [illegible] and the Engineer having [illegible] the retaining [illegible] by the establishment of [illegible] Fig 3. Here, as at Kaiapoi, the [illegible] bridge with its fall is attached to [illegible] which is at the time that I am now writing in the course of construction ~~progress~~. The natural [illegible] ~~upon~~ upon the bed, therefore, will take place between the [illegible] and the down stream side of the bridge precisely as is the case at Kaiapoi, in that instance, however, 2 intermediate falls have to be constructed, in the present there is only one.

The capacity of channel as excavated is reduced to the most economical limits, being [illegible] bottom width [illegible]

in width [illegible] the [illegible] [illegible] [illegible] of its length, the [illegible] [illegible] being at an angle of 45°

The cost of this Excavation was Co's Rs 3470. 0. 8 at a rate [illegible] per 1000 Cubic [illegible] equal to 1.9.58

The Drain [illegible] is constructed of Kunkur and [illegible] masonry the disposition of the materials being the same [illegible] [illegible] universally adopt^in these works^ [illegible] the Kunkur [illegible] procurable - [illegible] being used in the [illegible] and [illegible] [illegible] [illegible] joints [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as follows:

2 Parts Earth Lime
1 Part of Soorkee

[illegible] [illegible] of materials [illegible] ~~in the [illegible]~~ [illegible] [illegible] [illegible] at [illegible] [illegible] [illegible] [illegible] [illegible] ~~was~~ ^were^ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] following Table.

Rates of work	
Masonry	Rs. 12. 8. 6 p 100 Cubic Feet
Plaster	3. 0. 3 p 100 superficial Feet
Materials expended	
125640	Bricks [illegible] [illegible]
16918	Cubic Feet Earth Lime
9459	" " Soorkee

[illegible] The cost was, including the Cost of Excavation [illegible] Co's Rs 10487. 11. 7

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

The length [illegible]
Hindun River [illegible]
[illegible] 20 miles below [illegible]
[illegible]

[illegible] than those [illegible]
[illegible]

[illegible]

Distance from the Canal to the Hindun		5.3 443 [illegible]
Total fall from the bed of the Canal to the bed of the Hindun [illegible]		35.06 feet
Required slope for the bed of [illegible]	1.0	
Slope 5 chains [illegible] at 5 ft per mile	1.5	6.00
Balance left [illegible] Slope		[illegible]

[illegible]

[illegible] is ~~[illegible]~~ in progress
[illegible] Rs 1.?0,000 [illegible]

[illegible] road work [illegible]
[illegible]

[illegible]

[illegible]

2 Parts of [illegible]
1 [illegible]

The total quantity of material [illegible], and the cost [illegible] of the building, are exhibited in the [illegible].

521010	Bricks of various sizes
23156	[illegible]
11578	[illegible]

[illegible] Chester	14 7 11	per 100 cubic feet

[illegible] are [illegible] regulating [illegible].

[illegible] 13 . 14 . 3 . 7

[illegible] have been [illegible] passage through [illegible] have been [illegible] [illegible]

201.

the water, and to give her depth to the objects for which they were designed. The works in all three cases are completed as far as the original as the Engineer [illegible] the original plans, [illegible] to which is appended the [illegible] [illegible] [illegible] [illegible] [illegible] the present [illegible]; the condition of the [illegible] works, and the [illegible] for the [illegible] objects, [illegible] until the [illegible] of the [illegible] [illegible] the [illegible] sufficiently to [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] to the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] completed, [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]:

	Total required		Must give up		Surplus left	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kentucky Locks	1	3	1	1	–	2
[illegible]	1	2	1	1	.	1
[illegible]	1	4	1	1	.	3

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible] the [illegible] that the [illegible] [illegible] [illegible] [illegible] to [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the particular [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

12.

[illegible] [illegible] [illegible] [illegible] on
Plate XLVII [illegible] [illegible] —

[illegible] Trocadero [illegible] [illegible]

[illegible] [illegible] for the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] which takes place [illegible] the [illegible] [illegible] at the [illegible] [illegible] [illegible] [illegible] [illegible]

[[illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible]

The [illegible] that [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] by that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] of the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] it [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] it a great [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible]

The Moorish [illegible] Temple [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 15 [illegible] [illegible] [illegible]

Sig K. P. 120
Vol II Ch
Part III

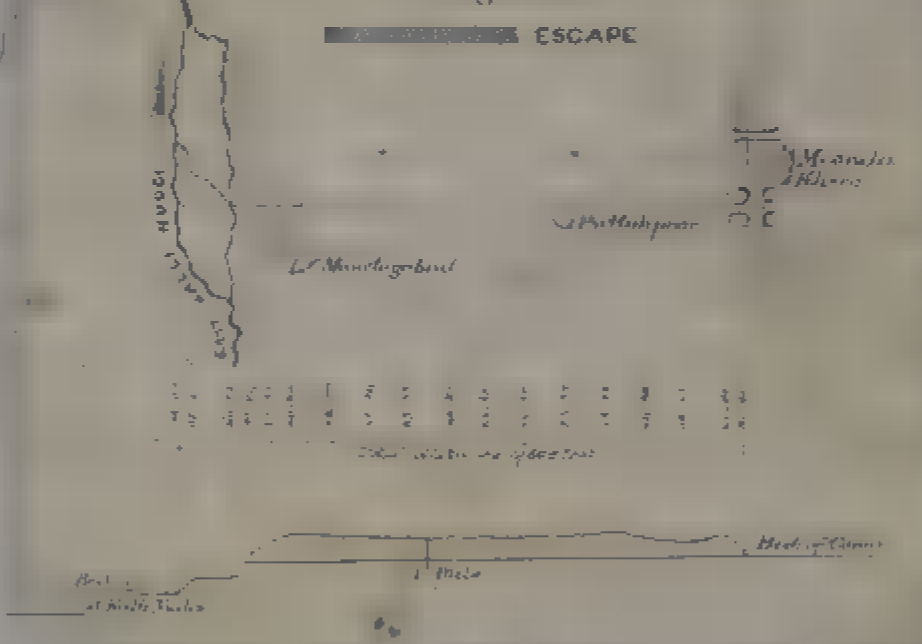
At the point at which [illegible] [illegible] is situated, the [illegible] has reached the [illegible] of [illegible] Sunnum and [illegible] [illegible] [illegible] with the East Calli Canal. The [illegible] Canal provides drainage to the [illegible] of the [illegible]

8 [illegible] for a distance of 11 [illegible] [illegible] of Treevoda [illegible] the East Calli Canal and the Canal [illegible] separated from each other by a [illegible] not exceeding 2½ miles and at a [illegible] about 1½ miles in width.

2 [illegible] The [illegible] was selected as being [illegible] [illegible] a [illegible] [illegible] between [illegible] the [illegible] the Excavated [illegible]

The following [illegible] with the [illegible] of the [illegible] [illegible] [illegible] but the arrangement [illegible] [illegible] [illegible]

Diag XCVI



Diag. XCVI

Distance from the main Canal to the head of the East Kalli Nuddee			9500 feet
Total fall from bed of Canal to bed of East Kalli Nuddee			16.74 feet
Fall slope for Escape head		1.00	
Slope of Channel at 15 ft per mile		2.69	3.69
Balance — Superfluous Fall			13.05 feet

So [illegible] two masonry [illegible] each with a drop of 6½ feet would be required. The leading descent [illegible] in masonry be built near the [illegible] [illegible] the [illegible] drainage Channel of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] from the [illegible] of the [illegible] [illegible] [illegible] into [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] 3 feet [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] excavated [illegible] a breadth of 66 feet with a bed slope of 1.2 per mile. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] completed.

[illegible] [illegible] [illegible] [illegible] [illegible] forms a component part of the [illegible] series of works connected with the Moorda [illegible] Bridge, [illegible] [illegible] is separated from that [illegible] the Bridge by a distance of 2434 feet. [illegible] [illegible] [illegible] [illegible] [illegible] to the Bridge [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the Bridge [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the right [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with [illegible] on the left.

The bridge which lies at a distance of 1½ miles [illegible] from the Town of Khoorja, acts as the main line of communication between that Town and the Country on the left bank of the East Kalli nuddee. Between the Bridge and the Escape head and in the centre is an Establishment of a 1st Class [illegible]. The buildings & the works are considerable in extent, and will I think be found to be conveniently situated.

The design of the head [illegible] in detail [illegible] that of the works before described. [illegible] built on the left or [illegible] side of the [illegible] and [illegible] consequently connected with the lowering of [illegible], it was necessary to maintain an unbroken passage along the [illegible]. In the beginning of the works [illegible] the [illegible] of the [illegible] [illegible] the causing of the embankment to an unnecessary height [illegible] which [illegible] [illegible] [illegible] [illegible] [illegible] At [illegible] [illegible] [illegible] both [illegible] [illegible] [illegible] is altogether of a more compact description and of a more uniform character than it was in the upper districts. The above advantages added to the [illegible] arrangements have as I [illegible] led to modifications of the plan before described. The sluices 10 in number are each of them 6 feet in width are arched over both on the full width of

the berm and Roadway so that a free passage is often [illegible]. the former being on a level with the Earthen berm, and occasionally depressed to an extent of 2 feet below that of the Road way. —

The Sluice Gates are worked by windlasses, and the usual apparatus through slits oftentimes situated between the berm and the roads, or the [illegible] Cultivation [illegible] which [illegible] the mouths of the Sluices are fitted with grooves in which planks [illegible] the flowing [illegible] that which [illegible] the [illegible] and [illegible] the [illegible] channel is 40 feet in length, or the full width of the work. The planks are [illegible] and [illegible] raised to a height of 1½ feet so as to admit of the [illegible] being [illegible] of [illegible] level. — A plan of this work is given in Plate XXXVIII of this [illegible].

The masonry walls [illegible] of brickwork and [illegible] of Stone [illegible] the [illegible] used being of the following proportions —

[illegible] to
100 [illegible] of [illegible] Lime

~~The total quantity of materials, and the rates at which the work was executed are shown in the following~~

The Moorundhra Escape Head ~~[illegible]~~ is a component part of the Bridge and was built at ~~[illegible]~~ in the cost of which it is included ~~[illegible] materials [illegible]~~ and the following

~~The work was begun in [illegible] by [illegible]~~ following are the rates however [illegible] in cutting.

The mason	15	.. ..	per 100 [illegible]
[illegible] do	10	.. 11	do
Plastering	[illegible]		per 100 sq. ft.
Whitewashing	[illegible]		do
Brick work	15		do
Wrought stone	10		do
Earthwork & Bank Planted	1	[illegible]	per 1000 [illegible]

[illegible] — Kattingpoor Weir [illegible]

[illegible] is [illegible] designed to that of [illegible] the [illegible] at Bunder [illegible] being [illegible] of the [illegible] [illegible] 17 [illegible] [illegible] which [illegible] made [illegible]

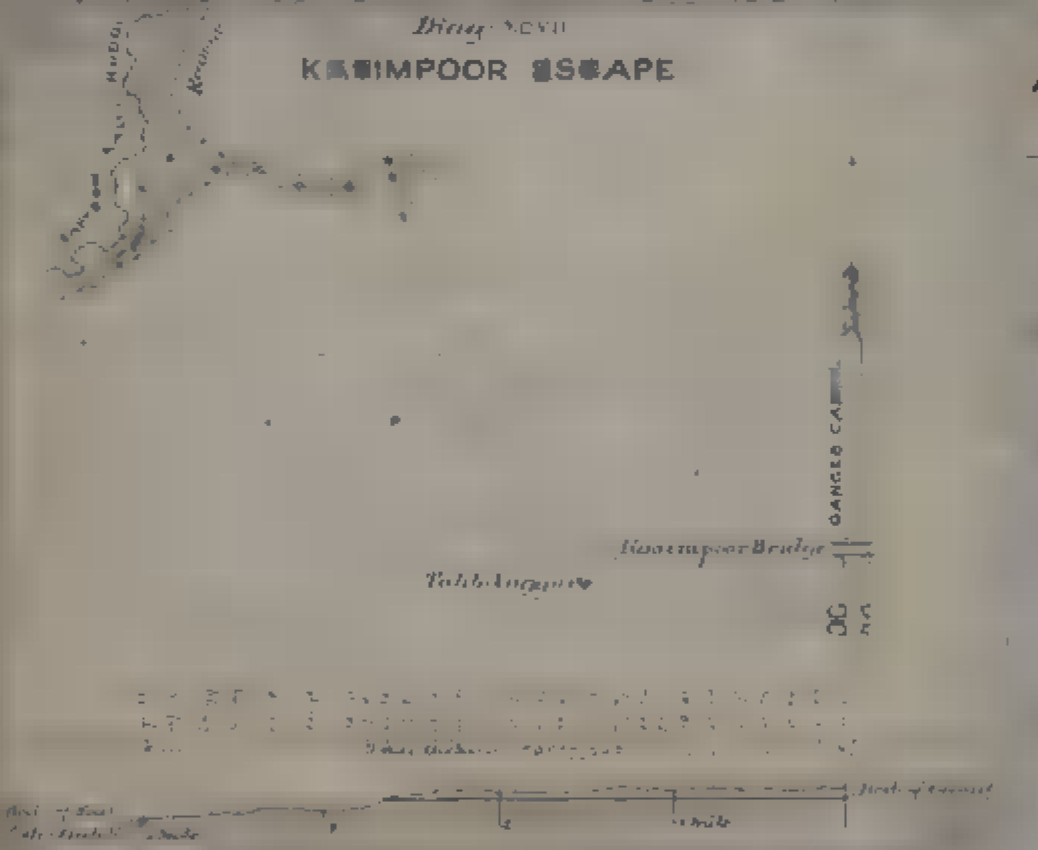
The [illegible] of the [illegible] at the [illegible] from [illegible] [illegible] the [illegible] of [illegible] the [illegible] [illegible] the [illegible] Regulator.

The [illegible] the Kattingpoor Weir is intended to [illegible] the [illegible] the Tank [illegible] and [illegible] the supply of the [illegible] which [illegible] [illegible] channel. [illegible] the Regulation of the supply into the [illegible] [illegible] into which the [illegible] [illegible] is divided [illegible] connected with the [illegible] [illegible] at [illegible] of [illegible] the [illegible] [illegible] water [illegible] lower [illegible] of the [illegible] —

The following Diagram [illegible] [illegible] the [illegible]

[illegible] provided [illegible] [illegible] [illegible]
[illegible] to the [illegible] [illegible]

B.83



[illegible] [illegible] [illegible] East Kali Nuddi		205.77 [illegible]
[illegible] [illegible] [illegible], East Kali Nuddi		21.35 [illegible]
[illegible] [illegible]	5.00	
[illegible] 5 [illegible]	6.00	7.00
[illegible]		14.35 [illegible]

[illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the East Kali Nuddi.

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] equal to 50 feet. the head [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] [illegible] is proposed to be attached to the [illegible] [illegible] of the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] constitute the head [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible]

of water compared to the [illegible]

The [illegible] construction of the waste-weir or Escape Head and the description of materials used are the same [illegible] as at [illegible]. The proportions of ingredients used in the [illegible] [illegible] as follows,—

1 Part Kunker Lime [illegible] E.
1/20th [illegible] Lime

~~The total quantities of materials and the rates of the work are shown in the following table.~~

The Waste-weir or Escape Head is (as are most of the [illegible]) a [illegible] [illegible] of the [illegible], [illegible] at that place in the cost of which it is included ~~[illegible]~~

~~[illegible] [illegible] used [illegible]~~

~~The [illegible] [illegible] [illegible]~~

~~[illegible] [illegible]~~

~~[illegible] [illegible] [illegible]~~

~~and~~ the rates [illegible] were as follows.

Arch masonry	15	pr 100 [illegible]
Other do	10 1 3	do
Plastering	2 11 11	pr 100 square feet
Metalling	2 1 6	pr do
Pile heads	15	[illegible]
Windlasses	10	do
Earthwork of Escape Channel	1 5	pr 1000 [illegible]

The work was commenced and completed by Mr Chief [illegible].

[illegible] [illegible]

[illegible] The [illegible] that they [illegible] have [illegible] into which they [illegible] up [illegible] [illegible] water [illegible] against [illegible] at any season of the year.

B. [illegible] in the [illegible] [illegible]

Under this [illegible] we [illegible] the works [illegible] regulating the [illegible] between the [illegible] [illegible] and the [illegible] [illegible]. The latter [illegible] in the [illegible] [illegible] to the [illegible] [illegible] of [illegible].

[illegible] be [illegible] the [illegible] in the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that the [illegible] [illegible] water [illegible] [illegible] [illegible] those [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] by [illegible] a [illegible] [illegible] the [illegible] the greatest [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the [illegible] part of the [illegible] in addition ~~and [illegible] [illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] and extracts of [illegible] [illegible] [illegible] to the [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] taken of the [illegible] [illegible] [illegible] [illegible] whilst [illegible] the [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of their [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

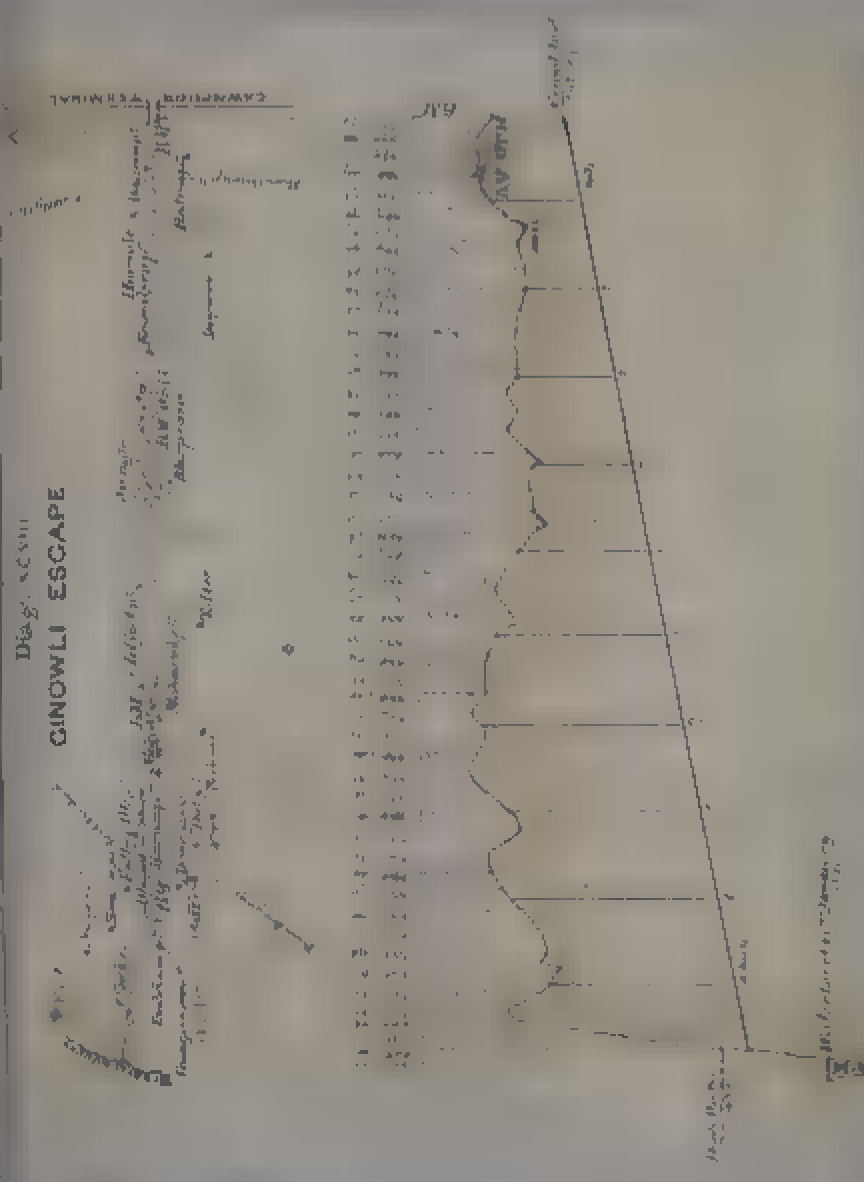
1. [illegible] [illegible] [illegible] [illegible]
2. [illegible] " [illegible]
3. [illegible] " [illegible]
4. [illegible] " 135 "

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] included in the chapter [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] connected with the [illegible].

1. [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] is connected is more [illegible]

[illegible]



[illegible] Diag XCVIII

[illegible]	10 miles 2.5 [illegible]
[illegible]	28.67 [illegible]
[illegible] Depth of Escape Head = 1.00	
Slope in 11 miles at 1.5 ft per mile = 16.50	17.5
[illegible] Superfluous Slope	11.17

[illegible] 2 [illegible] 1 5½ [illegible] 0.372 [illegible] 30 [illegible]

[illegible]

5/6th Kunkur Lime
1/6th Bujree.

[illegible]

	Bricks 3" [illegible]	Blocks Kunkur [illegible] cubic feet	Kunkur Lime [illegible]	Bujree Maunds
Masonry	86200	2270	5800	1136

Masonry of all sorts	Rs. 12 7	per 100 Cubic feet
Plastering	5 11 3	per 100 [illegible] feet

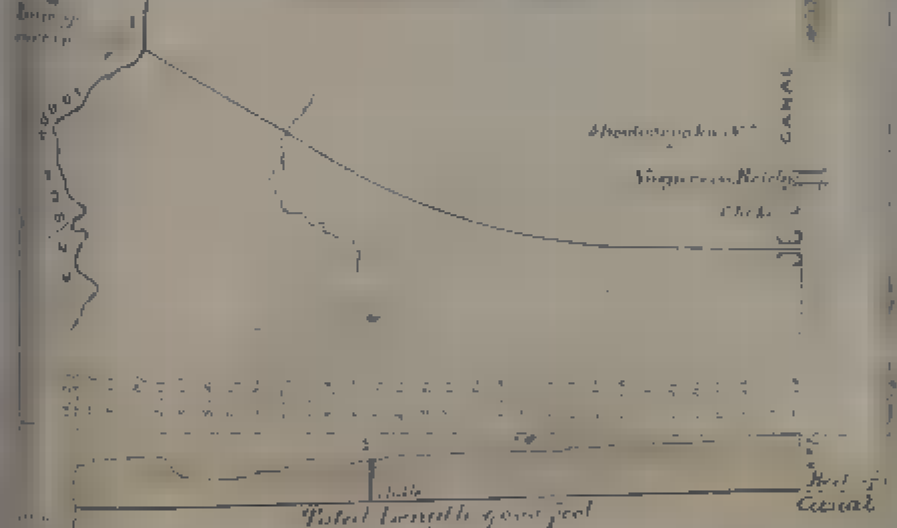
The present Escape was com-
menced [illegible] under the sub-
[illegible] of [illegible]
[illegible] Engineers, [illegible] a
cost of Co Rs 2213 .. 5 .. 9

No. 2. Nugureea Escape

Immediately above and
adjoining to the Nugureea bridge
which is situated at [illegible]
[illegible] a [illegible] of the
[illegible]
has been constructed. [illegible]
[illegible] It [illegible] the
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] of the [illegible] is [illegible]
[illegible]
its course [illegible] which the [illegible]
[illegible] Escape is [illegible],
through 36 [illegible] the [illegible]
[illegible] it has been [illegible]
[illegible] alteration with the
Canal! The [illegible] of
the [illegible] and the dimen-
sions of the works connected
with Escape, will be understood
by the following Diagram, the
head being situated on the [illegible]
[illegible] the Canal.

Diag: XCIX

NUGUREEA ESCAPE



[illegible]		9000 feet
Total fall from [illegible] sea of Escen[?]		5·42 feet
[illegible] at Escape [illegible]	1·00	
[illegible] at 15 [illegible]	2·55	3·55
[illegible] slope		1·87 feet

It is doubtful whether it may be necessary to [illegible] [illegible] [illegible] for the protection of the [illegible] [illegible] the [illegible] water [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the Escape, [illegible] [illegible] equally necessary for the [illegible] [illegible] of the agriculture. [illegible] [illegible] a bridge [illegible] the same [illegible], [illegible] adopted [illegible] [illegible] [illegible] in practice [illegible] [illegible] [illegible] [illegible] connection with a bridge the [illegible] [illegible] will [illegible] [illegible] [illegible] sufficient to [illegible] the [illegible] and to admit [illegible] the passage of water during the inundation, without the inconvenience [illegible] [illegible]. [illegible] [illegible] the [illegible] [illegible] [illegible] out that the additional supply of water [illegible] the proposed Escape [illegible] to the [illegible], will [illegible] the [illegible] of water [illegible] a Bridge built over the [illegible] near the Town of Mynpoora[?]
very desirable [illegible] bridge [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and Agra [illegible] in the last [illegible] years [illegible]

[illegible]

in a state [illegible] of [illegible] and [illegible], and the [illegible] [illegible] [illegible] approaches, which will [illegible] take place [illegible] the alterations which [illegible] [illegible] [illegible], will add greatly to the [illegible] of cross communication. The site of the [illegible] in [illegible] is 10 miles below the [illegible] of the [illegible] [illegible] and it is situated in a valley of [illegible] wealth, and [illegible] great beauty [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] line of [illegible].

The [illegible] [illegible] [illegible] [illegible] Times [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 30 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] not being connected with the Bridge [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
Escape heads
~~[illegible]~~

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

2 parts Kunkur Lime
1 part Buree

~~[illegible]~~ [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as [illegible]

Masonry		Bricks 3 [illegible]	Block Kunkur Cubic feet	Kunkur Lime maunds	Buree maunds
Masonry [illegible]		15	12	7	per 100 cubic feet
Plastering		2	11	6	per 100 cubic feet

[illegible] building [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at a cost to Company's Rupees 3340. 5. 11 -

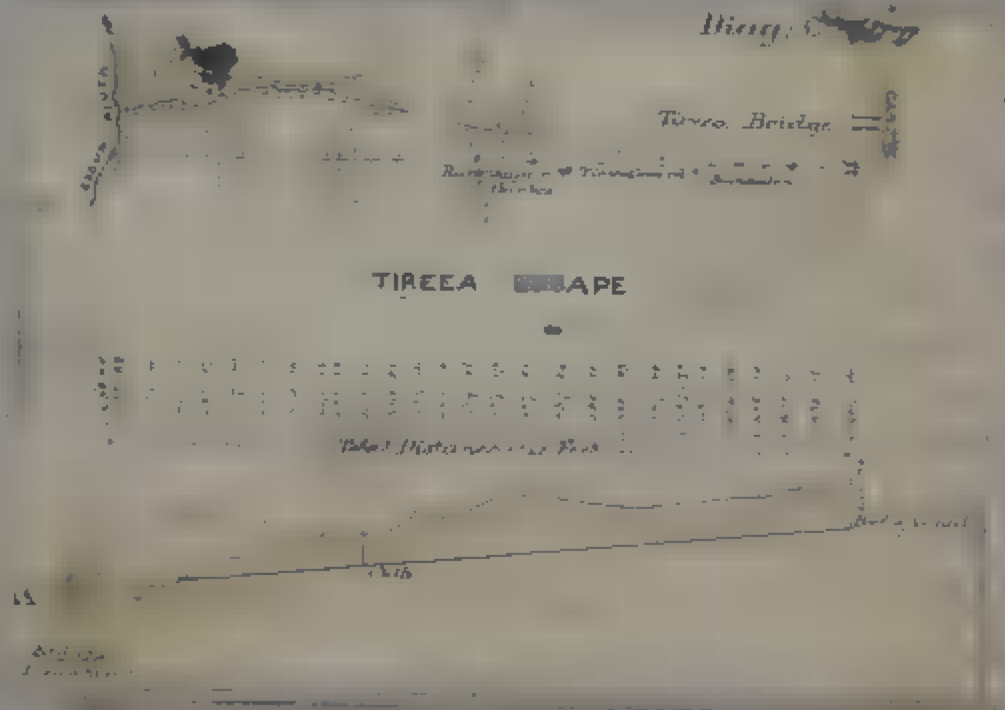
[illegible]

This [illegible] [illegible] the
[illegible] [illegible] [illegible] to
the [illegible] [illegible], to [illegible] addi-
tional water, the [illegible]
from [illegible] to the [illegible]. It will
be [illegible] [illegible] to the
[illegible], that it is [illegible] between
the 82nd and 83rd [illegible] and [illegible]
the village of [illegible] which
stands on the most [illegible] ground
between the [illegible] and the [illegible],
[illegible] [illegible] [illegible] afterward
[illegible] [illegible] the [illegible] on the
[illegible] the [illegible] [illegible]. I have
[illegible] [illegible], at the Museum,
[illegible] [illegible], [illegible] to the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible]. The [illegible]
[illegible] [illegible] [illegible] appropriate,
[illegible] [illegible] [illegible], and it has
been used as such [illegible] the [illegible]
[illegible] in the [illegible] ground.
It was [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] which
we had passed into the Museum.
[illegible] [illegible] to [illegible] it [illegible] that
purpose today, and with this
[illegible], an [illegible] [illegible]
the [illegible] [illegible] was [illegible] at
[illegible] [illegible] [illegible] [illegible],
[illegible] the [illegible] [illegible], [illegible]
[illegible] [illegible] the [illegible], and
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] its own
[illegible] [illegible] [illegible].

The [illegible] [illegible] [illegible]
[illegible] at [illegible] [illegible], the
[illegible] [illegible] [illegible] [illegible]
~~[illegible]~~
~~[illegible]~~ [illegible] the [illegible]
[illegible] [illegible] [illegible].

[illegible]

B.82



Length of Channel from Canal to [illegible] River	[illegible] feet
Total fall from bed of Channel to bed of River	[illegible]
Vertical Slope at Drop head 1.00	
Slope at 1.5 per mile [illegible]	[illegible]
Balance [illegible]	[illegible]

[illegible]

[illegible] about
1 part Kunkur Lime
1 part Bajree.

[illegible] quantity of [illegible] and the rates at the [illegible] [illegible] are [illegible] in the following table —

Bricks 3 [illegible]	Bricks 2½ [illegible]	Block Kunk[illegible]	Kunkur Lime maunds	Surkee maunds
38608	3625	11970	5563	4291
Masonry of all [illegible]		15 .. 1	pr 100 Cubic feet	
Plastering		2 .. 11 ..	pr 100 Supl feet	

[illegible] the Work was begun and [illegible] [illegible] at a cost to the Company of Rupees 2792 .. 10 .. 7

[illegible]

[illegible] that such [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible]

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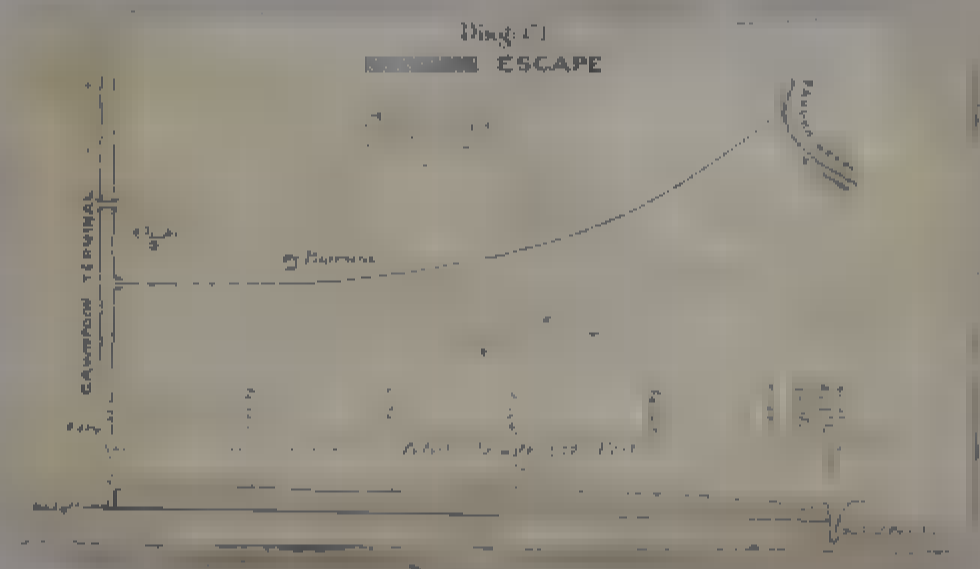
5

[illegible]

[illegible] Diagram [illegible]



Length of Channel from the Canal to Pandu River		5550 feet
Total fall from bed of Canal to bed of River		11·99 feet
Deduct slope of Escape Head	1·00	
Slope at 1·5 per mile	1·57	2·57
Balance [illegible] Drops		9·42 feet

[illegible]

[illegible] natural [illegible] very [illegible]
[illegible] it is evident that [illegible]
[illegible] necessity [illegible]
construction of [illegible]
[illegible]
[illegible]
[illegible]
[illegible] lines [illegible]
part of the [illegible]
[illegible] that the [illegible]
[illegible] 3 [illegible]
[illegible] from [illegible]
[illegible]
[illegible] Running [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the ~~road~~ obstacles
~~[illegible]~~ which have been
explained [illegible] addition
[illegible]
with the [illegible]. The Erie Canal
[illegible] distance of [illegible] miles, [illegible]
the [illegible] between
Albany and Buffalo is [illegible]
admirably adapted to [illegible]
[illegible] its capacity [illegible]
is great, and [illegible]
[illegible]
[illegible]
[illegible] the [illegible]
which constitutes the leading
work of the Canal building
and is provided with an [illegible]
equal to 36 feet in width [illegible]
addition to the [illegible]
[illegible]

[illegible] that at [illegible] the latter case the [illegible]

[illegible]

3/5th Kunkur Lime
2/5th Bujree

[illegible]

	Bricks 9 Inch	Block Kunkur cubic feet	Kunkur Lime maunds	Bujree maunds
Masonry	120808	3127	7626	5598

Masonry Rupees	14	5	8	pr 100 Cubic feet
Plastering	3	2	8	pr 100 Sup. feet

[illegible] Company's Rupees

32 Rs. 2. 10

Of the [illegible] for the purpose of regulating the Canal supply during the dry weather is [illegible]. By means [illegible] supply [illegible] during the [illegible] greatly [illegible] by the [illegible] which [illegible] at all seasons [illegible] advantage [illegible] which the [illegible] of [illegible] floods, [illegible] Land in [illegible] equal to the aggregate [illegible] which [illegible] to be [illegible] equal [illegible]

C [illegible]
Canal [illegible]

[illegible] the [illegible] the [illegible] regulating the Canal supply [illegible] head of [illegible] the [illegible] attached to the [illegible] described under the head [illegible] is situated at the 170th mile [illegible] with [illegible]

[illegible] Canal [illegible]

[illegible] to the [illegible]

[illegible]

side by the Rinde, on the other by the Nyngoor River. Between these two lines of drainage it continues constantly upgrade, in 14½ miles of its course, [illegible] [illegible] that it labours under the same disadvantages as the Cawnpore Branch, [illegible] so far that the Rinde in the early part of its course is not capable to provide the means of escape for surplus water as I have before described it to be. The Nyngoor River [illegible] on the right border of the slope along which the Canal passes, is also to be viewed as inefficient, or [illegible] [illegible] required in the early part of the progress from the [illegible] to the neighbourhood of [illegible] [illegible] [illegible] [illegible] deep than the Rinde, and is, of course at an earlier place better adapted to our purposes. At the 28th mile, the Channel of the Nyngoor, near the station [illegible] with the Canal, [illegible] under drainage [illegible] escape, or waste water. I regard it with [illegible] recollection that the Rinde at the 6th mile of the course was considered as incapable of being converted to a similar purpose. Below the points above mentioned both the Rinde and the Nyngoor gradually increase both in breadth and depth, and would admit of any additional supply that could be possibly turned off from the Canal.—

In determining the positions of Escapes, I have been

guided

[illegible]

[illegible] 1 [illegible] 5 [illegible]

2 [illegible] 103 [illegible]

3 Koora [illegible] 143 [illegible]

[illegible] 170 [illegible]

[illegible]

[illegible]

only as it lies at the right bank, and is joined to the Tyngyong river by an excavated channel; the width of the diversion waterway is equal to [illegible] in 6 [illegible] of 6 feet in width each: its design is similar in all respects to those which have been before described, and it is attached to the bridge by [illegible] in the usual way. — The ~~whole line of~~ works at Dihror may be considered as an ornamental appendage to the bridge [illegible] its passage across the [illegible] channel at that [illegible] point.

The [illegible] of the works in regard to [illegible] and to its relative position to the Tyngyong [illegible] will be understood by the following diagram.

(See Tracing (11))

Total length of Channel from Canal to Tyngyong R.	1 Mile 1090 feet
Total fall from the bed of the Canal to the bed of the Tyngyong River	10·17
Fall Slope at Escape head 1·000	
Slope on 1 M. & 1090 feet @ 1·5 [illegible] per mile 6·309	7·309
Balance Superfluous Slope	3·861

This superfluous slope [illegible] be arranged in a fall at the [illegible] superfluous [illegible] [illegible] [illegible] to [illegible] [illegible] works in the [illegible] of channel between it and the Tyngyong [illegible] without [illegible] to the bridge. [illegible]

[illegible]

No. 1 Uttu Ghunfa — 5 miles
2 Trinkuta — do — 102 miles
3 Reeva — do — 113 miles

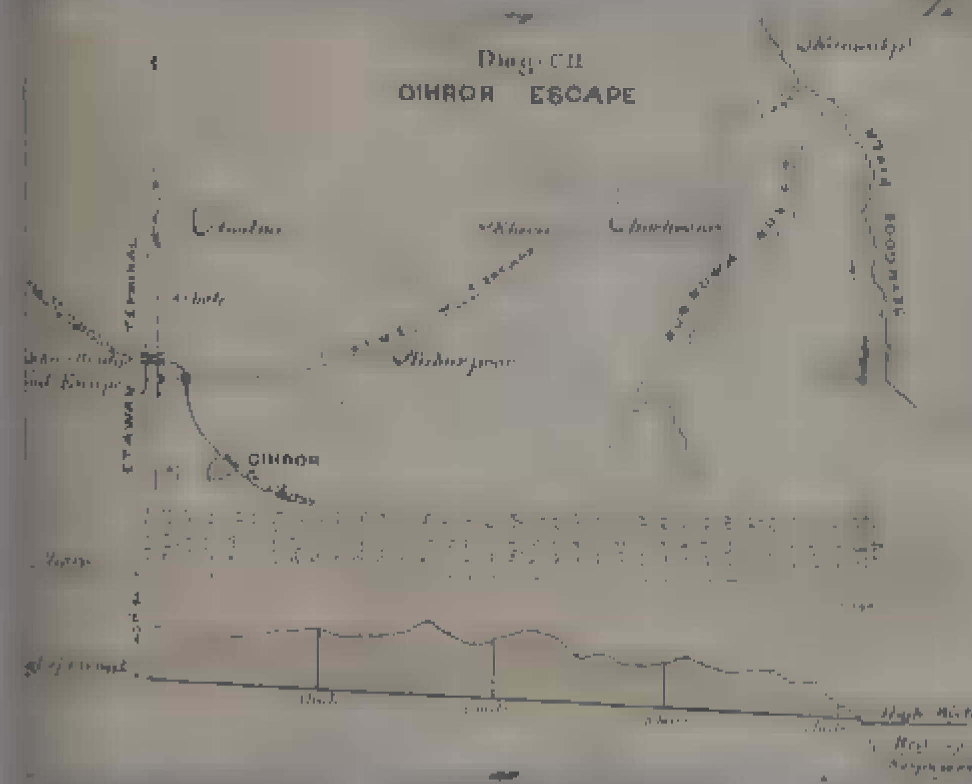
[illegible] 170 miles.

Tab. Ttu Ghunfa

[illegible]

and Agra, it lies on the right bank and is joined to the Sygoon River by an excavated channel; the width of its three waterways is equal to three [illegible] 5 [illegible] 8 feet in width each: its design is similar in all respects to those which have been before described, and it is attached to the Bridge by [illegible] in the usual [illegible]. The ~~[illegible]~~ works at Chihror may be considered as an example of [illegible] [illegible] [illegible] and [illegible] its position [illegible] the Escape [illegible] at that [illegible] [illegible].

The [illegible] of the Escape in regard to the Canal bed, and to its relative position to the Sygoon [illegible] will be understood [illegible] the following diagram.



Vide Dist. Diag. (CII)

Length of Channel from Canal to Sygoon R. [illegible] 1090 feet

Total fall from the bed of the Canal to the bed of the Sygoon River		10·17
Fall [illegible] Escape Head	1·000	
[illegible] 1090 feet [illegible] 15 [illegible]	6·309	7·309
Balance Superfluous [illegible]		3·861

The discrepancy [illegible] might be [illegible] [illegible] by a fall at the [illegible] [illegible] [illegible] [illegible] has been done [illegible] [illegible] [illegible] to admit [illegible] [illegible] of [illegible] in the bed of channel between it and the [illegible] without [illegible] [illegible] to the [illegible] [illegible] [illegible]

we have [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] which [illegible] would [illegible] the [illegible] [illegible] [illegible] [illegible] in the works' even in the shape of the fall above proposed, such an arrangement would [illegible] [illegible] place the works in peril [illegible] — In high floods in the [illegible] the water rises to a depth of between 6 and 7 feet; on these occasions there would be back water in the Scarps channel, affecting the [illegible] [illegible] [illegible] [illegible]

The Scarp [illegible] [illegible] been [illegible] in a rectangular trench of 20 feet width, depth equal to the width, the depth [illegible] [illegible] [illegible] to 15 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] what has been done by [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] on the calculation [illegible] [illegible].

[illegible] [illegible] has been [illegible] [illegible] in the [illegible] [illegible], the [illegible] [illegible] [illegible] used in [illegible] [illegible], which has attended [illegible] [illegible] [illegible] [illegible], has been of great service in [illegible], the completion of the work.—

The ~~proportions~~ of [illegible] used in the [illegible] is

Pure [illegible] Line

[illegible] [illegible] [illegible] masonry [illegible] [illegible] [illegible] [illegible] [illegible]

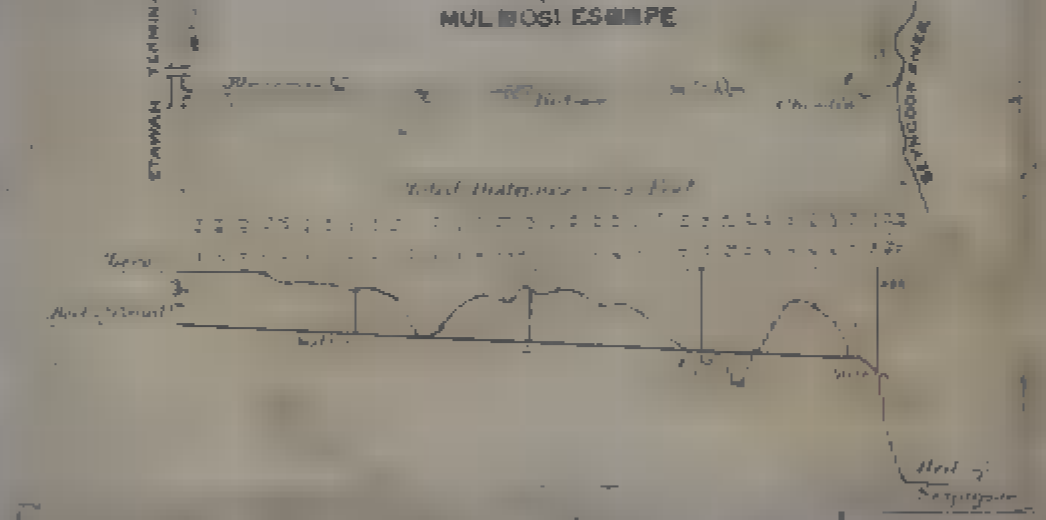
22676·2 Cubic Feet at an average of
Rs 12..13.10 pr 100 cubic feet

The Work or Escape was begun and completed by Sub Overseers of the Engineering Co. as Executive Officer, the Assistant Engineer having superintended its execution and looked after the progress in all its details. The total cost of this work was, exclusive of Regulating apparatus which will be fixed hereafter, Rs. 2417.. 3.. 2

No 2 Mulbosi Escape

This work which is situated at the 113 mile at a point [illegible] feet [illegible] the Canal [illegible] the [illegible] which [illegible] well [illegible] to 31 feet [illegible] feet [illegible] water into the Sengor River.

The [illegible] of the [illegible] the [illegible] and the Sengor River [illegible]



Length of channel from the Canal to the Sengor River		1 mile 537 ft
Total Fall from the bed of the Canal to the bed of the Sengor River		25.89 ft
Total Slope at Escape head	1.00	
Slope at bed 882 per feet = 1.37 per mile	6.16	7.16
Balance Superfluous Fall		18.73

To [illegible] the [illegible] of [illegible] and [illegible] ment lien, [illegible] descents of [illegible] with a [illegible] of [illegible] each will be necessary, the [illegible] as usual being connected with a [illegible] passage, ~~[illegible]~~ This [illegible] may be [illegible] as the [illegible] of [illegible] [illegible] Rajbaha [illegible] the [illegible] line of [illegible] takes [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] a [illegible] [illegible].

[illegible] proposed line of [illegible] [illegible] the [illegible] [illegible] the village of [illegible] [illegible] passage ~~[illegible]~~ intersects a good deal of [illegible] [illegible] [illegible] [illegible] ought [illegible] be [illegible] with [illegible] the [illegible] of [illegible] the [illegible] [illegible] to the village [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] without [illegible] and [illegible] with the [illegible] [illegible] [illegible] the ~~[illegible]~~ tortuous course that [illegible] [illegible] [illegible] [illegible]. The [illegible] [illegible] a distance of a [illegible] [illegible] the [illegible] and between [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] at this point the [illegible] course of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] the [illegible] below the [illegible] Combinations —

There are very great advantages in maintaining a long cutting in a straight line so that there may be as little impediment as possible to the free flow of the upper waters and interruption to the [illegible] which depends [illegible] the [illegible] of the work. [illegible] with [illegible] the Canal [illegible] capacity [illegible] from its [illegible] the [illegible] bearing upon the [illegible] at the point of [illegible] with the [illegible] I would [illegible] the [illegible] the [illegible] that [illegible] may be used to direct the [illegible] and to the [illegible]

The section of [illegible] the [illegible] will be [illegible] is the same as that at Gilner viz. rectangular on a width of 25 feet with slopes equal to the depth of digging; the bed slope equal to 15 foot in a mile.

This work is not yet begun.

No. [illegible] Rona Embt.

This work is situated at the 13th mile. It throws the water into the Ganda [illegible] from which it is separated by a distance of 17,500 feet and the [illegible]

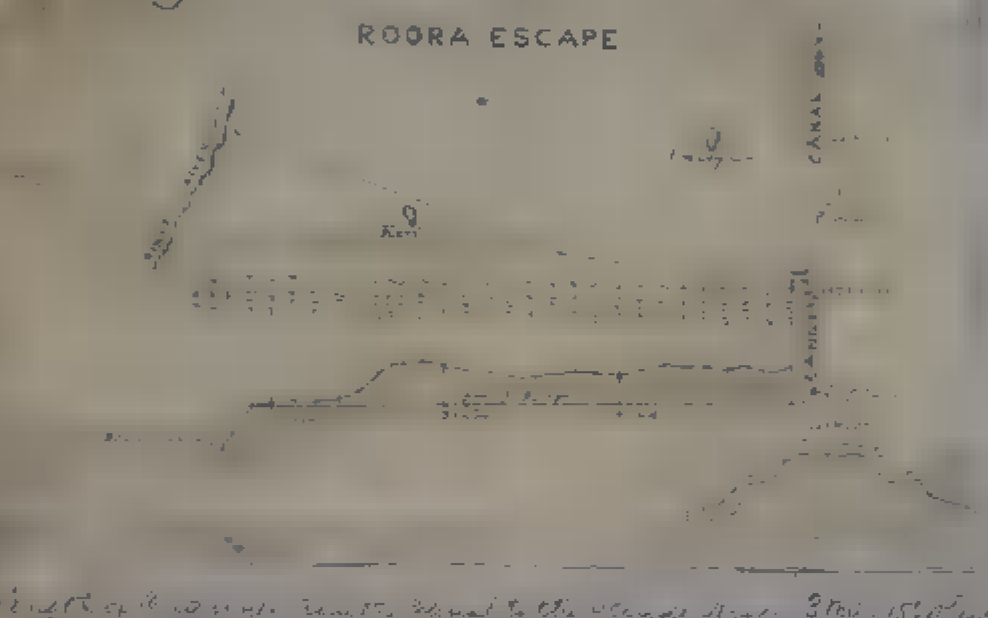
[illegible]

[illegible] the [illegible]
the [illegible] ~~[illegible]~~ on
the [illegible]
[illegible] the double purpose of [illegible]
[illegible] the [illegible]
[illegible] of the Canal [illegible]
[illegible] drainage [illegible]
[illegible] to the Canal [illegible]
[illegible] by [illegible] surplus
[illegible] water.

The Roora Escape
[illegible] the Canal [illegible] the villages
of Roora and [illegible], at which
point the [illegible] to be
[illegible]
[illegible]
[illegible]
[illegible]. The [illegible]
[illegible]
[illegible] breadth of 18 feet
[illegible]

The [illegible] Escape is
[illegible]
[illegible]
[illegible]
[illegible] between
[illegible]
[illegible]

Diag: CIV



Length of [illegible] to the [illegible]		3 m. 1500 feet
[illegible] from the bed of the Canal to the bed of the [illegible]		15 . 16
[illegible] Escape [illegible]	1.00	
[illegible]	4.93	5.93
[illegible] superfluous slope		16 . 25 ft

[illegible]
[illegible]
[illegible]

the fire, it may be convenient with reference to the [illegible] that [illegible] appear to [illegible] to [illegible] the [illegible] [illegible] [illegible], without [illegible] to [illegible] [illegible] [illegible] [illegible] [illegible]. I would, [illegible], recommend that all [illegible] [illegible] should be [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], to meet the [illegible] [illegible], [illegible] [illegible] appear to be [illegible] [illegible] [illegible] [illegible] [illegible]; but, [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible]. There is a [illegible] [illegible] [illegible]. The [illegible] [illegible] [illegible] [illegible] and the [illegible] [illegible] [illegible] to [illegible] the greatest [illegible] [illegible] [illegible] channel [illegible] [illegible] [illegible] [illegible] [illegible] that has been done at the [illegible] [illegible] [illegible]; this method [illegible] [illegible] the [illegible] channel [illegible] water, and if the rail is built at a distance from the [illegible] [illegible] exceeding 80 a 100 feet, there can be no danger to the [illegible] [illegible].

The [illegible] [illegible] [illegible] from the head to the [illegible] is proposed to be 30 feet, with additional [illegible] [illegible] to the

[illegible]

whilst the present will provide capacity for carrying the [illegible] body of water as well as that for the drainage [illegible] to additions [illegible] the drainage connected with these works, part II and diagram LIII should be consulted. —

At the time that I am writing the works on the [illegible] [illegible] are not sufficiently advanced to bring them in contact with the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] which will greatly facilitate the completion of [illegible] works that [illegible] [illegible] ~~[illegible]~~ [illegible] [illegible] [illegible] that the Roora [illegible] will be [illegible] [illegible] and be built on the standard plan [illegible] [illegible] of [illegible] [illegible]. —

The [illegible] [illegible] regulating the supply [illegible] [illegible] [illegible] [illegible] [illegible] what had been [illegible] [illegible] has been [illegible] in a great measure to that of the [illegible] [illegible] connected with the [illegible] irrigation [illegible] [illegible] with [illegible] [illegible] in the [illegible] of regulating the water. In the case of the Roora [illegible] the position of the work is [illegible] [illegible] connected with [illegible] drainage. The arrangements [illegible] to the [illegible] will I think be sufficient for the required purpose.

[illegible] [illegible] [illegible] [illegible]

[illegible]

[illegible] which lies behind the Roora - Gorge is that of the 17th mile which as the upper [illegible] [illegible] [illegible] works into the European [illegible] will be described in the [illegible] devoted to those works. I may remark however that the [illegible] had [illegible] towards the Eastern trails of the [illegible] which [illegible] immediately below the Roora Gorge, [illegible] ultimately [illegible] to the [illegible] of [illegible].

[illegible] which have been discovered under the beds of the Rutherford [illegible] and [illegible] as well as the [illegible], are all [illegible] with [illegible] [illegible] [illegible] [illegible] has been [illegible], and [illegible] the [illegible] was only [illegible] [illegible] 1883. [illegible] [illegible] the [illegible] been adopted [illegible] the [illegible] beds [illegible] completing them [illegible], the [illegible] [illegible] independent [illegible] [illegible] at [illegible] the advantages [illegible] [illegible] [illegible] already [illegible] on the [illegible] [illegible] of the [illegible] [illegible] and design [illegible] [illegible] [illegible].

emphasize so as a position to remedy any defects and to supply any deficiencies.—

IV. Falls or Drops

to overcome Superfluous Slope.

In projecting the slopes of a canal bed and after determining the amount of the [illegible] of the country upon which the [illegible] it is to be carried, it becomes necessary to dispose of the superfluous fall by artificial means, either by means of [illegible] [illegible] of falls, and [illegible] [illegible] of a [illegible] [illegible] nature [illegible] [illegible]. The longitudinal [illegible] is [illegible] in a [illegible] [illegible] the [illegible] and the height of fall being determined by the [illegible] of the country.

On the Ganges Canal there are with the exception of the last 2 miles of its course [illegible] [illegible] the [illegible] [illegible] to the [illegible] bridge which [illegible] consists of [illegible] and [illegible], and to which a slope of [illegible] has been given, and of the [illegible] 2 mile [illegible] [illegible] [illegible] which have a slope of 1½ [illegible] per mile.* The slopes in [illegible] case [illegible] 1.25 ft, and [illegible] [illegible] maximum of 1.57 [illegible] of 1 foot per mile, [illegible] 3 [illegible] of its course, [illegible] [illegible] at [illegible] intervals, the [illegible] [illegible] act as [illegible] of the [illegible]

~~* as well as of particular [illegible] of the Ganges Canal [illegible] slopes designed for special purposes~~

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] equal to the [illegible] amount of the [illegible] [illegible] [illegible] [illegible] to take place, the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 2 or 5 feet. The [illegible] of the [illegible] under such extreme circumstances would be [illegible] [illegible] [illegible] in all cases where the [illegible] [illegible] [illegible] [illegible] [illegible] in a light [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] together [illegible] wooden frames, [illegible] ~~[illegible]~~ [illegible] [illegible] by an [illegible] [illegible] of [illegible].—

[illegible] from 1½ to 1 [illegible]

[illegible] [illegible] [illegible] natural [illegible] [illegible] [illegible] [illegible] [illegible] ~~[illegible]~~ artificial [illegible] to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and it will [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of additional [illegible] [illegible] [illegible]

[illegible]

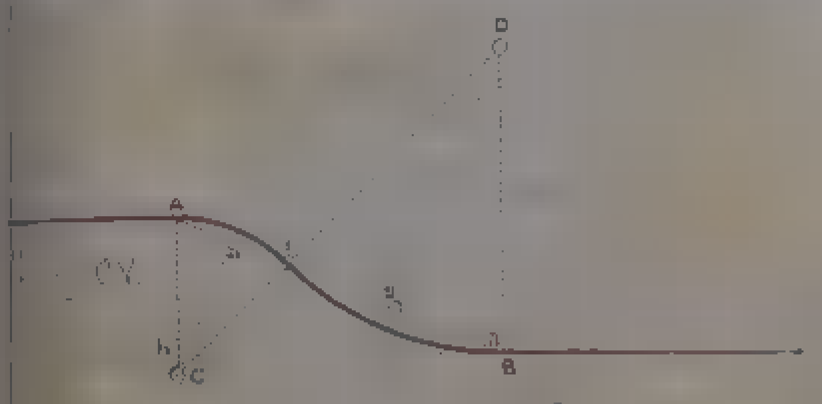
[illegible] b[illegible] it is not [illegible] to take the volume of the [illegible], it becomes [illegible] [illegible] this [illegible] upon the [illegible]. –

[illegible] [illegible] an [illegible] the estimate of the Eastern Branch Canal as a [illegible] put into execution, appears to me to have at least the merit of practical applicability to circumstances attendant on the [illegible] [illegible] [illegible] to [illegible], relating to the [illegible] ~~[illegible]~~ view of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] in construction, [illegible] in the [illegible] of the [illegible] of water which [illegible] [illegible] to [illegible] in the [illegible], the [illegible] [illegible] [illegible] may [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], with [illegible] to the [illegible] as an [illegible] [illegible] the [illegible] to [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the [illegible].

Without entering into mathematical computations of the value of the [illegible] [illegible] which are supposed to be best adapted to the purpose, [illegible] [illegible] suggest [illegible] considerations [illegible] [illegible] [illegible] by M. Bossut in his book [illegible] ~~[illegible]~~ diques [illegible] ([illegible] [illegible]) [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] numerous [illegible] upon the [illegible] [illegible] this Province.

[illegible] Panama Canal [illegible] the most satisfactory [illegible]. The [illegible] is represented by the following diagram.

Diag CV



$I.B = \frac{3\,AB}{2}$

$AI = \frac{AB}{3}$

AC } Perpendicular
DB } [illegible]

Bisect AI [illegible] of D [illegible] AC at C [illegible] DB [illegible] D
From the points C and D [illegible] the curve.

[illegible]

[illegible]

[illegible] *(above line: almost)* [illegible] either, [illegible] Leather, by [illegible]

[illegible] (161 – M. Vol. [illegible])

[illegible]

[illegible] course [illegible] contact [illegible]

[illegible]

of [illegible] [illegible] [illegible] [illegible]

Also in [illegible] [illegible] of the [illegible] [illegible], without going so far as Jumna and the Chambal the [illegible] falls along which [illegible] the water [illegible] [illegible] great [illegible] [illegible] Vindhya Range. [illegible] [illegible] [illegible] [illegible] ~~[illegible] [illegible]~~ – [illegible] Kate falls has a [illegible] [illegible] upwards [illegible] feet. The [illegible] of water [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] which had [illegible] [illegible] [illegible] the volume is said to be tremendous. I have a vivid recollection of an excursion made [illegible] [illegible] [illegible] my [illegible] the late Edward Smith of the Bengal Engineers [illegible] [illegible] [illegible] during the rains [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible].

Of the second case, the Jumna [illegible] its junction with the Ganges at Allahabad [illegible] the [illegible] from its junction with the Jumna upwards, and the [illegible] [illegible] [illegible] of the [illegible] Doab, of which so much has been written in these [illegible] [illegible] [illegible] [illegible]. The [illegible] [illegible] through high land, with all its details of [illegible] [illegible] [illegible] drainage, is well [illegible] in the regions where the [illegible] [illegible] [illegible] [illegible] [illegible] which they are tributaries. In the [illegible] of Agra [illegible] the Jumna flows through [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

and in company with the water
deteriorating the Swatow [illegible]
the British territories [illegible]
a [illegible] of [illegible] and [illegible]
[illegible] the wealth of which is
[illegible] thunder [illegible],
the [illegible] to which I have
alluded, although with a volume
of water [illegible] conforma-
-tion [illegible], [illegible] the [illegible]
front of their courses, attended
by [illegible] of a [illegible]
[illegible] to the [illegible]
River, and to an extent that
would hardly be credited
by those who overlook the causes
and the length of time through
which these effects have been in
operation. —

Although however it may
have been convenient to the [illegible]
[illegible] to view the action of
water as above described under
two separate heads, it must not
be overlooked, that the whole
question [illegible] which
[illegible] is really
one of degree. That in both the
cases which I have above mention-
ed, [illegible] and [illegible]
to reduce them to the [illegible]
[illegible] and that the perpendicular
[illegible] which nature gives
to [illegible]
a [illegible] to the [illegible]
[illegible] and [illegible]
away and [illegible]
to the [illegible]
[illegible] would have [illegible]
[illegible] of time.

[illegible] constitution
of [illegible] to the

[illegible]

[illegible] below the [illegible] would not [illegible] but the [illegible] [illegible].

[illegible] XXI [illegible] Bahadurabad [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] 20 feet, [illegible] 10 feet distance [illegible] of the [illegible] on the upper [illegible] [illegible] feet distant [illegible] [illegible] of the [illegible]. It appears [illegible] the [illegible] [illegible] in which the [illegible] [illegible] it is [illegible] [illegible] [illegible] [illegible] attention to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] a [illegible] of water [illegible] [illegible]

in length, 183 feet, presents [illegible] without intermission [illegible] and con-
tinuous volume.

[illegible] natural
cataracts [illegible] over
which the water pours, nor the
[illegible] into which it falls, are in
the smallest degree constant, for
one perpetually undermining, [illegible]
the other [illegible] subject to [illegible]
[illegible]. The natural rock is
[illegible] and [illegible]
[illegible]
Cataract. The artificial fall is
a collection of small pieces [illegible]
[illegible] into one
mass by the [illegible]
It is in no way connected with
the bed [illegible];
[illegible] in [illegible] ways [illegible]
[illegible]; [illegible] circumstances
[illegible] which it is constructed
render the bed [illegible]
constant [illegible] to
[illegible]
[illegible] which has not been touched
by the [illegible], it is [illegible]
[illegible] water,
and [illegible] water that has no [illegible]
[illegible] sympathy with it.

[illegible]
[illegible] this question [illegible]
[illegible] all [illegible]
[illegible] must [illegible] view that
[illegible] itself, and [illegible]
[illegible] with the [illegible]
that in [illegible] we have
[illegible] as we are
[illegible]
[illegible], [illegible]
[illegible] of the [illegible] and [illegible]

of this sort, would be the nature of
the material with which we are
obliged to construct our buildings.
[illegible] are so tenacious, [illegible]
[illegible] water equal to that which
I have [illegible] above, the perpendicu-
lar fall would be insufficient;
it would in my opinion be
expensive and dangerous and
useless than the common measure
that, for [illegible] mass of brickwork
or any [illegible] stone be able to
[illegible] stand the concussion, and
the [illegible] action of the water
in the [illegible].

Although discussing a
principle I have used the ex-
pression "expense" in the preceding
paragraph, ~~and~~ This [illegible] would
be [illegible] our falls have been
[illegible]
[illegible] the [illegible] of the pe-
[illegible] and [illegible] plan.
The Reservoir [illegible]
must have been [illegible] in depth
the height of the fall, [illegible] must
[illegible] sides [illegible]
[illegible] built of
the [illegible] masonry [illegible]
[illegible] supposing that
[illegible] must have been
most [illegible]. In [illegible]
[illegible] the Fatta Falls [illegible] the
foundation [illegible] actually laid
21½ feet below the [illegible],
and where I was obliged to [illegible]
[illegible] the reservoir at the [illegible]
the [illegible] at the [illegible],
in consequence of the [illegible]
difficulties that we had to [illegible]
[illegible] it, the cost of perpendicular
falls with their [illegible]
and [illegible] would have been

enormous

reservoirs - The same remark
would apply to the falls and [illegible]
[illegible]
[illegible] the pre[illegible]
[illegible] that of
the [illegible].
[illegible]
[illegible] first [illegible]
[illegible]
[illegible] back water
thrown upon the foot of the falls
[illegible]
the water may be allowed to pass
[illegible] perpendicular [illegible]
[illegible] water [illegible]
[illegible]
=pendicular [illegible] without the [illegible]
[illegible] reservoirs, the
[illegible] on the [illegible] is the
[illegible] of the [illegible] perpen-
dicular falls [illegible]
[illegible] that [illegible]
[illegible] steps [illegible]
back water is disposed, perpen-
dicular falls, [illegible] moderate
[illegible] are inapplicable [illegible]
the height or amount of fall is
great and where the volume of
water is large, that [illegible]
[illegible] necessary, however, that
[illegible] applies to the [illegible]
of the [illegible] in these [illegible],
and more especially to the Ganges
Canal. On the [illegible]
[illegible] ([illegible] instance)
where the slopes are moderate
and the volume of water smaller
perpendicular falls might per-
haps be substituted for the [illegible]
[illegible]
[illegible]
[illegible] necessary,

as the cost of [illegible] would absorb
any saving that might be contem-
plated in reducing the length of
the tail [illegible] walls, [illegible] walls
[illegible] frequently used as the
support [illegible] for cross commu-
nication. [illegible] nothing
would be saved. With regard to main-
tenance and against the effects
of falling volumes of water upon the
[illegible] of [illegible] such [illegible]
constructed might be worthy of
consideration.

[illegible] some
may be [illegible] [illegible]
[illegible] [illegible]
[illegible] the perpendicular fall would
[illegible]. In
the [illegible] there [illegible] falls each
with [illegible] situated with
[illegible] 45 [illegible]; to imagine
the [illegible] that would be raised by
the continuous [illegible] of [illegible]
of water over [illegible] perpendicular
[illegible]
[illegible] disappoint [illegible]
[illegible] I have constructed

I have proceeded to a [illegible]
[illegible] on the above subject I have
[illegible] and it
[illegible] that has [illegible]
thought, and the views that I have
adopted have only been decided on
after mature deliberation. Fully
appreciating as I do the advantages
[illegible]
[illegible] that I have
[illegible] the perpendicular
[illegible]
[illegible]
[illegible] the nearest
possible [illegible] the advantages
[illegible] in this stage

[illegible] to [illegible] plan [illegible] have [illegible] Castle [illegible] to reject the [illegible] plan [illegible] required [illegible] with [illegible] imposed [illegible] in all probability [illegible] of [illegible] the [illegible] were solely of [illegible] nature [illegible] of any particular purpose.

[illegible] make of the [illegible] of the fall, the [illegible] upon which it mainly [illegible] have been determined and [illegible] noted [illegible] Diagram CV.

The falls themselves may be divided into three groups.

I The Budha Gunga [illegible] upper part

II Do. Do. [illegible] part

III Do. Do. [illegible] part

I. The [illegible] upper part

[illegible] are [illegible] to the [illegible] [illegible] following [illegible]

1. [illegible] ([illegible] Falls)
2. [illegible] (Garrison [illegible])
3. Do. ([illegible] Falls)
4. [illegible] ([illegible])

[illegible] the [illegible] passages [illegible] parts of [illegible] described [illegible] passages.

[illegible] Falls [illegible]

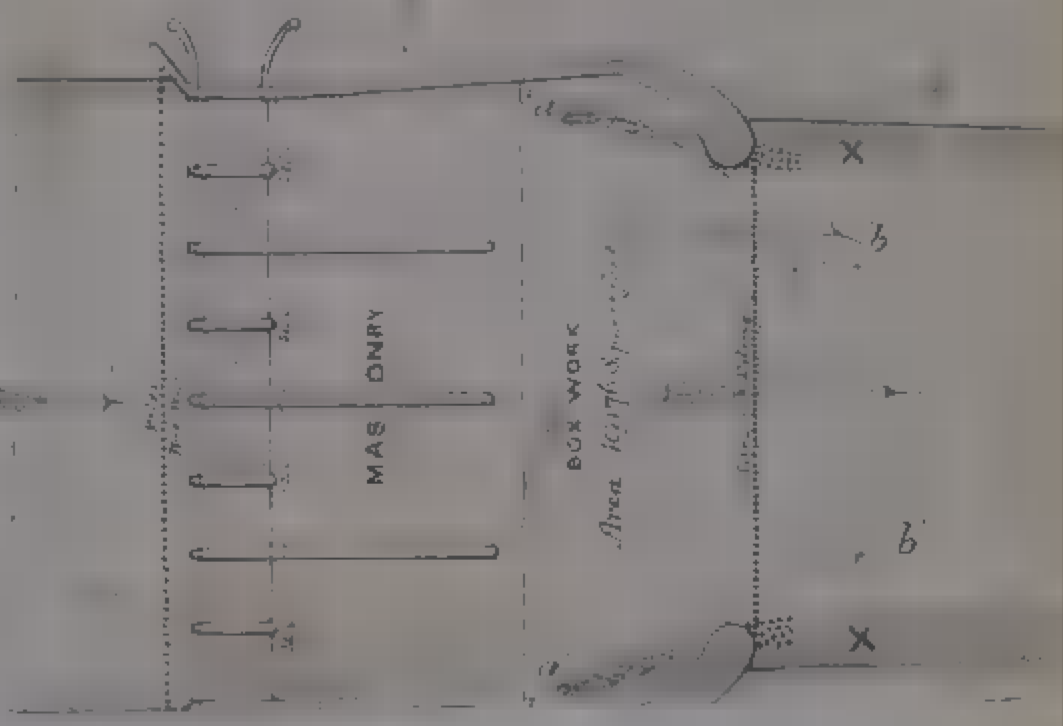
Bridge, at a distance of 5 feet in width, each pier [illegible] the Canal on the upper side, but the last of the bridge [illegible] are attached diverging walls, with four chambers of 52½ feet each in width. Every [illegible] timber flooring, [illegible] arranged on the Abutment face, so as to diminish the space which is occupied by the lower flooring with its [illegible]: in advance of these diverging walls which are carried to a distance of 84 feet from the Abutment face of the bridge, there is a [illegible] space of [illegible] flooring, which is protected by an advanced wooden [illegible] work, of heavy materials filled with stones [illegible], and covered with sleepers, so as to retain the materials in position. Additional defences are [illegible] to [illegible] by [illegible]. The [illegible] of the chambers below the [illegible] are protected by [illegible] quay walls [illegible] the direction of water. This plan is [illegible] to [illegible] the alignment of the Bridge abutments, [illegible] and [illegible] at the [illegible] of 20 feet in width. At a distance of 3½ feet from this point, the [illegible] make a slight curve [illegible] (on [illegible] along the [illegible] next to the Abutment) — In [illegible] projecting jetties. Between and on the [illegible] of [illegible] jetties, [illegible] of piles, [illegible] protection arrangements are

air distribution, so as to insure the safe passage of the boats and [illegible] [illegible], and to admit of the [illegible] escaping from the [illegible] with as little tendency to damage as possible. The object [illegible] the section of upper foundation walls [illegible] equal to 21 feet [illegible] of the tail walls [illegible] [illegible] and Pillars is also [illegible].

[illegible] the plan of this work [illegible] refer to the Atlas, Plate XXI [illegible] following outline in Diagram [illegible], will show the general design, and its introduction here will

The following outline in Diagram however, will show the general design, and its introduction here will

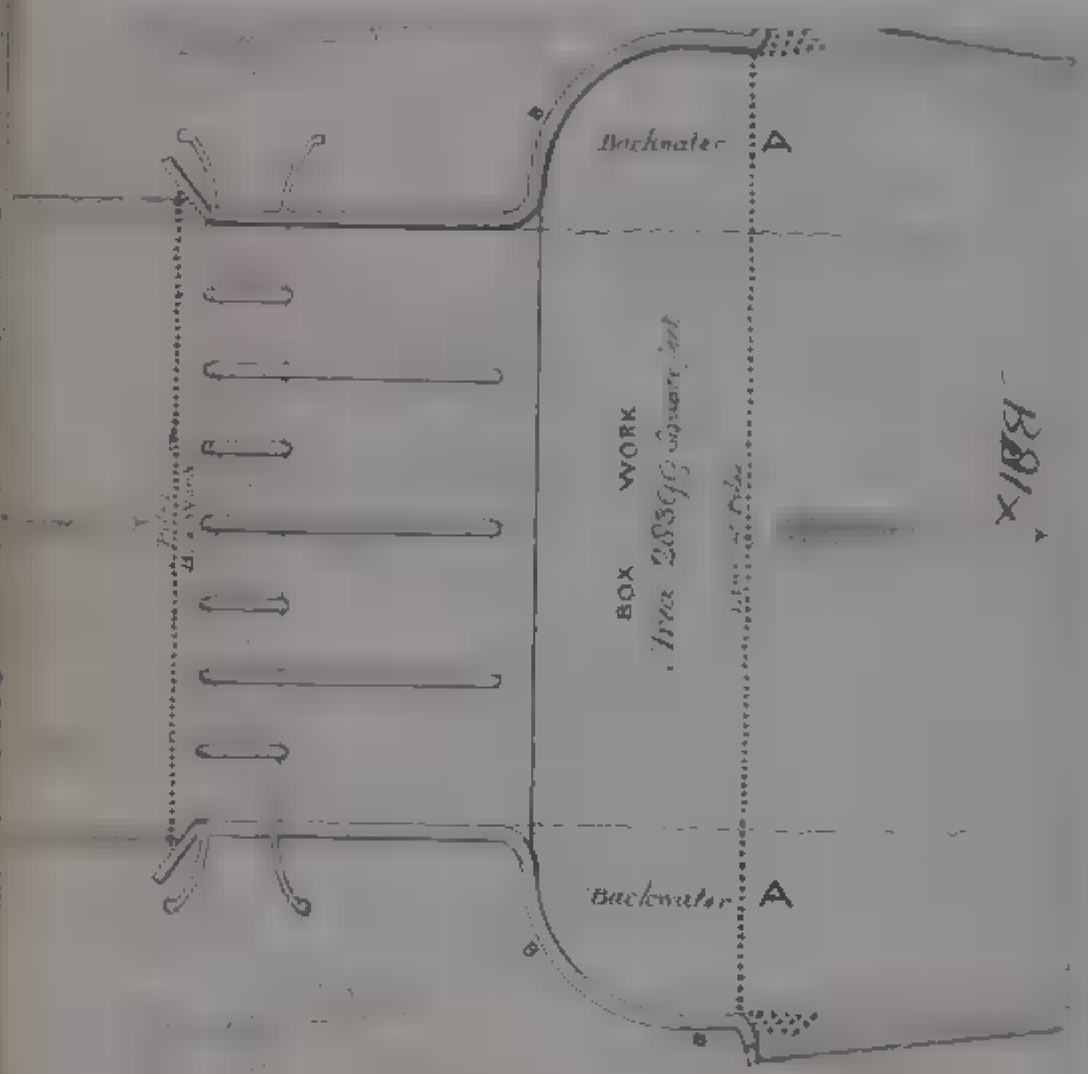
Diag CVI.



enable me to describe the views by which I have been guided in arranging the sluice constructions in [illegible] of the plans, and in [illegible] to secure a safe [illegible] for the [illegible] of the [illegible] [illegible].

[illegible] the plan [illegible] represents the [illegible] of the Falls [illegible]

... on the [illegible] ... with the exception of those at Beira, the [illegible] described have been executed, I shall [illegible] outline of the works at Beira [illegible] position [illegible] [illegible] shown on the [illegible] diagram, the explanation [illegible] about to offer may be easily comprehended.



The above Diagrams represent [illegible] plans [illegible] [illegible] [illegible] Diagram CVII. being the original design upon which the works [illegible] at Beira [illegible] [illegible] Diagram CVI. [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] walls have been completed.

[illegible] [illegible] works of the [illegible] [illegible]

and uninterrupted passage for the current on the verge, without turmoil and agitation attendant on the passage of the water over the sills; to relieve the current from all provocation, irritation and vexation, on its passage from the masonry to the earthen channel; and finally to use every precaution and expedient not only to direct the current upon the centre of the canal channel, but if possible to maintain it in that position on its onward movement.

The plans shown in the above diagrams may be taken as 'active' and 'passive' examples of works designed for the purpose of obtaining the desiderata above mentioned. Diagram CVI (Active) being so designed that the currents sweeping along the cut of the flank walls in the 'curved wing' as shown by the arrows a.b. a'b', shall, by impinging on the main body of water on its escape from the masonry building, act like a physical aid to retain the current in a centrical position, and at the same time afford protection to the slopes at x x.

Diagram CVII (Passive) leaving the desired objects to be attained by back water as shown at the points A A.

Both of these designs have advantages peculiar to themselves; that of Diagram CVII is in use generally on the Eastern Jumna Canal, first being substituted in

masonry

masonry revetments on the curves
B B) That of the CVI. Diag. [illegible] is new, and has not yet been tried. The latter, however, has the merit of being more compact than the original design, and of being greatly more economical in its con-struction. It was in fact the enormous excavations which were required at the falls at Belra, the difficulty of disposing of the earth, and carrying out the embankments, and the extensive area demanding revetment at the tail, that led me to the modi-fication as exhibited in Diag: CVI.

The [illegible] built as drawn in Diag: CVI represents the falls which I am now describing, it will be observed that they are protected at the head by a continuous line of sheet piling, between which and the body of the work frame [illegible] with cushions are placed, the cross and cushions being retained in position by straps nailed onto the pile heads. A similar line of piles it will be observed runs [illegible] the ends of the jetties [illegible] the front on the down stream side of the frame, between which and heavy material that occupies the space enclosed by the body of the work and the bank revetments, This protective area of heavy ma-terial has a slope of 1/5 feet to the down stream side, That on the upper surface which acts as an apron to the whole work of the fall has a similar slope downward to the upstream di-rection. The [illegible] and top [illegible] at the upper [illegible]

lower levels are strongly protected by piling, the detail of which will be best understood by referring to the Atlas.

The up & downstream sides of the deep lines its foundation on the up and downstream sides, built transversely across the Canal. The thickness of the flooring over which the water passes is six feet; it rests upon very hard clayey soil, and with the exception of the upper layers is constructed entirely of boulders and Kankar cement; the abutments, walls, piers, arches and superstructure generally are of brick masonry.

The object in dividing the lower flooring into chambers by division walls, was to afford the means of repairing, and for this purpose the Regulators at the top of the Falls have been designed both for [illegible] the admission of sleepers or iron planks, let down from the roadway, worked by windlasses ~~wound are~~ attached to ratchets fixed into masonry blocks. This line of ratchets and windlasses, both ends of sleepers [illegible] as a parapet to the roadway on the upstream face of the bridge. On the downstream face a masonry wall gives security to the line of communication.

Steps are attached to the wings of the Bridge so as to give the means of access to the platform on the top of the [illegible] [illegible] both lights and [illegible] [illegible] [illegible] [illegible] [illegible]

the top of the Division walls
from the upper roadway. - No 2
Falls being situated on the high
road between [illegible] and
Hurdwar, has a bridge roadway
equal in width to 25 feet. -

The Cement used in this
work was composed of

1 Part Stone Lime.
1 " Soorkee
1 " Sand

The total quantity of material
used, and the rates of the
different species of work, are
tabulated in the following table

P. Bricks	12" x 6" x 2½"	923500	
Do	12" x 6" x 2"	728900	
Boulders	— —	317225	maunds
Khanka	— —	10919	Cubic feet
Stone Lime	— —	75310	"
Soorkee	— —	71418	"
Masonry Rates	—	12 9 4	pr 100 Cub feet
Plaster	—	4 13 11	pr 100 Sup feet

These works were built under
the superintendence of Captain
Goodwyn, and cost, exclusive
of Regulating apparatus
which was still to be fixed
Companys Rupees 72788. 8. 11

No 3 Bahadrabad Falls
are constructed at a point in the
canal alignment where there
was a deviation of 5½° from the
direct line, to meet this obliquity
and to give the Current a bearing
upon the new direction, a cor-
responding obliquity has been
given to the flanks and Chamber
walls, the plan of construction
may be understood from the lines
in Plate XXII of the Atlas, while
the laying out of this work is
[illegible]

Segment diagram. The work is in fact built on a curve, the segment is a circle whose radius is 1,661 feet. With the exception of the peculiarity in the laying out, the details of building, both in material and dimensions are precisely the same as those at the No 2 Falls. The depth to which the curtain wall or foundation on the upper level is carried, and that of the tail and its flank revetments and jetties is equal to 20 feet.

The mortar used in this work was composed of

1 Part stone Lime
1 .. Soorkee
1 .. Sand

The total quantity of material used, and the rates at which the work has been executed are exhibited in the following table.

Bricks 12"x6"x2½	1431220	
Boulders	326088	Maunds
Shingle	7910	Cubic feet
Stone Lime	75993	do
Soorkee	77670	do
Masonry [illegible]	11 7 1	per 100 cubic ft
Plaster	4 3 5	per 100 s feet

These works were also built under the superintendence of Capt Goodwyn and cost exclusive of the Regulating Apparatus which has still to be fixed Company's Rupees 67613. 10. 3

II. — [illegible]

Under this item are included the works of the Masonry Falls extending from [illegible] [illegible] to the [illegible]

16th

106th [illegible] — [illegible] may be divided
into 2 classes depending on their
[illegible] situations, the 1st class
being of equal extent to that in
the Roorkee works; the 2nd being
diminished in consequence of the
reduction of Vertical volume
in the Canal depending on the
abstraction of 1240 cubic feet per
second for the Futtehgurh Branch
supply, to the expenditure from
[illegible] heads; and on other causes
depending on Escapes. No reduction
[illegible] take place until the
Canal has passed the heading
[illegible] at Roorkee, up to which
point it is liable on emergency
to be [illegible] with water (which
may be turned off over the above
Branch) in addition to its own
supply.

The Falls, bridges, & [illegible]
may be classed under the following
heads.

1st Falls with a waterway of 200
feet in width.

Asufnugger Falls at the 26th mile
Mohummudpoor — do — 31st — do
Belra — do — 42 — do
Jaoli — do — 48 — do
Chitowra — do — 55 — do

2nd Falls with a waterway of
150 feet in width.

Salawa Falls at the 60 mile
Bhola — do — 64 — do
Dasna — do — 106 — do

With exception of ad-
ditional [illegible] to the Bridge
superstructure which is depend-
ent on the [illegible] [illegible]
and depth of dredging, the design
for the works in [illegible] [illegible]
[illegible]

is similar in every respect to that of the Falls in the Khadir [illegible] I have before described. The Bilau[illegible] Falls which I have pointed out as a solitary instance of deviation from the General plan in the flank and tail arrangements, is in other respects also similar.

In accordance with the views which I have alluded to in the commencement of these papers, I shall at the expense of being considered tedious, enter into more detail of the different works, noting the peculiarities connected with the soil and foundations; quality of material used in the construction, and variations in the details of design, which although trifling in themselves, may be [illegible] of [illegible] [illegible] – I [illegible] in the order of precedence we have [illegible] in the [illegible].

The McGregor Falls.

This work which is at [illegible] at the [illegible] mile [illegible] on the [illegible] in Division VI [illegible] with [illegible] [illegible] – The [illegible] have been constructed [illegible] with exception to the [illegible] of [illegible], which [illegible] [illegible] [illegible] [illegible] [illegible] are [illegible] by a [illegible] which [illegible] the [illegible] from the top of the [illegible] to the [illegible]; [illegible] the [illegible], [illegible] pretty [illegible] to the

[illegible]

one end of wall, and partly in [illegible] [illegible] balls, [illegible] with [illegible] among [illegible] [illegible] in the [illegible] undecorated cells.—

The [illegible] of [illegible] the partitions [illegible] and [illegible] the [illegible] are in the same plan as those described [illegible] material which the partition is given [illegible] of [illegible] XI [illegible] brought [illegible] observations in the [illegible].—

The formations are [illegible] of a nature [illegible] that had the excavations not been made in the [illegible] sand and at a distance [illegible] suggested that this had been sand in the bed of a [illegible]. I may here draw attention to the quantity of sand [illegible] that [illegible] throughout the [illegible] of the excavation [illegible] with the [illegible] deposits. In many [illegible] in practice [illegible] with the stratified deposits. They [illegible] the [illegible] of [illegible] but [illegible] a tabular [illegible] stalactite [illegible]; and [illegible] the [illegible] of the sand [illegible] of the [illegible], but [illegible] stones or rools. The formation is entirely distinct from that of the [illegible] deposits which [illegible] of [illegible] and clay [illegible] in all probability [illegible] of sand [illegible] of affinity.

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[illegible] surface sand, are found distributed throughout the land of the [illegible] numerous ~~them~~ on ~~out~~ in our Country, it is common [illegible] to expect them in this place. T[illegible] specimens of fauna and [illegible] [illegible] in the native's districts [illegible] ~~[illegible]~~ calcareous sandstone [illegible] the Ulhaul, [illegible] and [illegible] which [illegible] [illegible] and oblong form, [illegible] [illegible] extent, [illegible] with great [illegible] and [illegible] produce it is said an excellent [illegible].

To come to the foundations of the [illegible] walls, which are [illegible] in the sand [illegible] laid in sand. The whole of the walls are constructed [illegible] the [illegible] sides of the [illegible] rest upon [illegible] walls [illegible] to a depth of 20 feet; and used during the construction [illegible] for the purpose of supplying water to the town; these [illegible] are [illegible] on all occasions. The [illegible] on the [illegible], or on the upper [illegible] is 20 feet in depth, and 8 feet wide; that on the [illegible] is 20 feet in depth and 10 feet wide. The [illegible] out of the [illegible] and [illegible] thickness, and the whole [illegible]

is constructed on the [illegible] dimensions is [illegible] in Plate XXXI of the Atlas.

The bricks which were used were made in the vicinity 12" x 6" x 2½" in dimensions, and the proportions of the cement were as follows:-

1 Part Stone Lime, and from 1 to 2 parts of Soorkee according to kind of work

The quantity of materials used, and the rates of building are shown in the following table.-

Bricks	12"x6"x 2½"	3467766	
— Do —	small —	150000	
Boulders		8236	Maunds
Jhama		6210	Cubic feet
Stone Lime		65860	— "
Soorkee		85135	"
Masonry including [illegible]		17	3 11 per 100 cubic feet

The work which was built under the Superintendence of Captain Goodwyn cost, without the Regulating apparatus which has still to be fixed, Co's Rs 91,419. 0. 6.

The Mukhmoodpoor Falls

The most remarkable feature in the construction of these works, was the extraordinary [illegible] and [illegible] nature of the sand on which the foundations are laid. The sand in fact was of such a nature, that the whole building was laid in a [illegible] water & [illegible] situation, it being next to impossible without imminent danger

danger to the work [illegible], to at-
tempt [illegible] excavations
the sand, as at Assofnuggur,
was accompanied by the concretion
which have been before described.
The front foundations & those
which lie transversely across the
Canal [illegible] act as a wall
upon the [illegible] of the water,
[illegible] to a depth of 32½ feet, a
[illegible] wall gradually [illegible]
[illegible] in width to the upper
[illegible]. The wall in the progress
of construction was [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] in the [illegible]
[illegible] at Assofnuggur.
The [illegible] wings and attendant
[illegible]
[illegible] to a depth
of 40 feet; the general details of
the [illegible]
[illegible] and material are similar
to those at Assofnuggur
[illegible]
the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] from the
[illegible] the lower side of the
[illegible]; the [illegible] wings are
[illegible] by steps to the [illegible]
of [illegible] the Canal to the
[illegible] either the [illegible]
[illegible] the wings are
[illegible]
[illegible].

The [illegible] and the
[illegible] with all their
attendant details [illegible]

for work, which executed in these works with the greatest care, and is possessed with greater attention to stability than usual. [illegible] The plan is the standard one, used [illegible] at this [illegible]

The bricks which were used in this work were generally [illegible] made from [illegible] 12" × 6" × 3" [illegible] dimensions; a number of old bricks from the ruins of the [illegible] were also [illegible] in [illegible], but the flooring [illegible] coated with [illegible] [illegible] with bricks which were specially laid aside for the purpose [illegible]

The [illegible] and [illegible] are [illegible] of hardwood, and the [illegible] almost with [illegible] [illegible], consists entirely of [illegible] brought from the [illegible]

The proportions used in [illegible] were as follows:

1 Part Stone Lime
2 Parts Soorkee

The quantity of material used, and the rates of building [illegible] given in the following table.

	Cubic Feet Masonry	[illegible] Sq. [illegible] Plaster	[illegible] Bricks of all sizes	Stone [illegible]	[illegible]
Masonry	45180	36362	3386.0	[illegible] 7286	150.3.5

Masonry [illegible]	12	10 6 [illegible]
Plastering	4	14 2 [illegible]
[illegible]	6	14 [illegible]

The [illegible] was [illegible] by [illegible] Bute Fraser of the Bengal Engineers. The superintending [illegible] all the [illegible] and [illegible] forming the [illegible], [illegible] to the work was [illegible]

Execution.

executed under the supervision of a Resident Head, and the Cost was, exclusive of Regulating apparatus which was still to be fixed [illegible] of Rupees 86,461. 2. 8½.—

The [illegible] Falls

It appears from the published [illegible] that [illegible] upon I found the works [illegible] and, with the last foundation walls laid in [illegible] operations [illegible] in 1875.

[illegible] what has been done before that the design of the ground plan of the [illegible] Falls, differs from that of the others, [illegible] the design [illegible] the same [illegible] Plate [illegible] of the Atlas.

The [illegible] foundation [illegible] to a depth of 25 feet [illegible] that [illegible] to a depth of 20 feet, [illegible] the [illegible] the caisson [illegible] [illegible]. The [illegible] though sandy, the [illegible] situated immediately [illegible] the extremity of a ridge [illegible] (Bhoor) [illegible] tolerably consistency [illegible] a sufficiently [illegible] nature to admit of the excavation [illegible], without the inconvenience and [illegible] that have been [illegible] with [illegible]. The dimensions of the floorings, the elevation of the bridge and [illegible], and the details of the [illegible]

[illegible] the Mall-
-and Crossing. The whole work is
built of Brick Masonry the
bricks 12" x 6" x 3" being burnt
in kilns situated in the neigh-
-bourhood; here, as at Mahmoodpur
the greatest care has been given to
the selection of the hardest class
of bricks for the flooring, edges,
and those parts of the structure
which are exposed to the con-
-stant attrition of water.-

The protective arrangements
both on the upper and lower levels
are as shown on the standard plan,
and the boxes have been filled
with 12 or 18 inch ring boulders
the procuring of which at this
distance from the hills is a matter
of very great difficulty.-

The extent of [illegible],
adapted to the plan on which
the two last falls of this work
are built, is very great and
the amount of work in the pucca
or total length proportionally
so. A comparison between the
areas represented in Diagrams CVI & CVII
will show that the first is to the
last as 1 is to 1.4569 & that the
quantity of work in the last for
the brick paving is half as much
again as that in the other: I
have noted on the face of the
Diagrams the actual areas of
the two floorings.-

The proportions used in
the cement were as follows:-

2 Parts of Earth Lime
1 " of Soorkee

The total quantity of materials
used, and the [illegible] [illegible]

The

the work was built are shown in the following table. —

	Contract work		Additional [illegible]		
	[illegible] masonry	[illegible] Plaster	[illegible]	[illegible]	works
masonry	36,6370	36560	2472775	132123	66062

masonry of all sorts including Plaster —	13 4 4 per 100 Cubic feet
Pointing	6 11 5 per 100 square feet

The Bilra tanks were commenced under Lieut. Fraser's superintendence, and were brought to completion by [illegible] [illegible] [illegible] all the protection arrangements have been executed. The cost of the work was, exclusive of the Ventilating apparatus which was [illegible] [illegible] [illegible] [illegible] Rs. 93.3.6

The [illegible] Tanks

These tanks are similar to those at Muchumgudda, but the rock on which they are founded is of a different description, the first foundation [illegible] is 32½ feet in depth [illegible] 8 feet [illegible], the [illegible] [illegible] is 20 feet [illegible] the design is on the caisson system which is [illegible] throughout the [illegible] in elevation and dimensions the design corresponds with the standard plan [illegible] [illegible] of [illegible] [illegible] [illegible].

The [illegible] and protective arrangements are similar in every respect to those before described, the heavy [illegible] with which the [illegible] are filled consisting of [illegible] blocks. —

The main mass of this building is formed of new rods, with a proportion of the small native brick, excavated from ruins in the neighborhood. The mortar consists of the following ingredients

2 Parts of earth Lime
1 Part of [illegible]

The quantity of material used, and the rates of the work are as follows: –

	Contents of work		Materials expended		
	Cubic ft of masonry	Superficial Plaster	Bricks No.	Cwt Lime	[illegible]
Masonry	36,136	[illegible]	2753175	12237	61188

Masons' accounts	12 7 8	per 100 cubic ft
Plaster	4 " 4	per 100 superficial
Metalling	7 1 9	per 100 cubic ft

The [illegible] [illegible] [illegible] commenced by [illegible] [illegible], and finished by [illegible], under whose supervision the [illegible] of the [illegible] [illegible] [illegible] [illegible] have been executed. These [illegible] [illegible] [illegible] [illegible] the [illegible] apparatus which [illegible] [illegible] [illegible] [illegible] to £1368. 11. 10½ –

The [illegible] Walls. –

The depth of the front curtain foundation walls of this work is equal to 14½ feet, on a width of 8 feet. The rear or back wall is 8½ feet deep, on a width of 4 feet. – In other respects the [illegible] is identical with that at [illegible].

The walls [illegible] constructed almost [illegible] [illegible] [illegible] native small brick from [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible]

of Chitowra. The flooring, [illegible] and other parts subject to the attrition of the current have a superficial covering 12 inches in depth of the best burnt [illegible] bricks selected for the purpose.

The spur boxes which constitute the protection to the head and tail of the work are filled with one foot cubes of brick masonry no other material being available. The piling and woodwork in general are executed in the same [illegible] place.

The cement used in the works consists of the following ingredients

[illegible] 2 of [illegible] lime
[illegible] part of [illegible]

The quantity of material used and the rates of the work are as follows:

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Masonry	216995	36562	227747	10566	58635

Masonry [illegible]	11	11	[illegible] per 100 cubic [illegible]
Plaster	3	3.6	per 100 [illegible]

The Chitowra falls were commenced under Lieut. [illegible] and completed under [illegible] superintendence; [illegible] the regulating apparatus which will be fixed hereafter. Cost [illegible] Rupees 55132..13..8 —

[illegible] the Chitowra falls, the 1st series, or that with a width of waterway equal to 200 feet terminates. The advance there is a reduction of 50 feet in the width which brings us to the

2nd Series, which ~~contains views of [illegible]~~ commences with

The Sulawun Falls

This work is situated at the [illegible] from the [illegible] regulator. Work a new [illegible] dimensions [illegible] are [illegible] a new [illegible] of [illegible] foundations, [illegible] being built with [illegible] depth [illegible] in the [illegible] walls, blocks [illegible].

The design of these works and the [illegible] [illegible] to [illegible] [illegible] [illegible], [illegible] the [illegible] of [illegible], [illegible] as to at [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] in the [illegible], and 3 Chambers [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in other respects [illegible] with the [illegible] [illegible] falls. [illegible] [illegible] the protective arrangements [illegible], which are [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] at the Sulawun Falls is [illegible] [illegible], and it [illegible] the [illegible] [illegible] at moderate depth [illegible] [illegible]. The [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible], have been [illegible]. The [illegible], and [illegible] [illegible] upon the [illegible] [illegible] [illegible] the [illegible] [illegible] of 12½ feet [illegible] [illegible] on the [illegible] [illegible] [illegible] in caissons, [illegible] [illegible] with the [illegible] [illegible] the [illegible], [illegible] [illegible] wall, [illegible] [illegible] [illegible] [illegible] [illegible] a depth of 18 feet. The [illegible] foundations [illegible] upon

a line of floats, and are [illegible] to a depth of 12 feet - [illegible] and are lines of piles and boxes filled with heavy material and in grooves to the work from the action of the waves. The details of these [illegible] are [illegible] are similar to those [illegible] [illegible] - Blocks [illegible] [illegible] the [illegible] to the neighborhood [illegible] used as heavy material for filling the boxes.

The [illegible] [illegible] 12" x 6" x 3" [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] material.

The mortar consists of the following ingredients:

2 Parts of [illegible]
1 Part of [illegible]

The quantity of material used and the value of the work [illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Masonry	39,5368	[illegible]	2440.60	104,456	[illegible]
Masonry of all sorts including Concrete	13128	per 100 cubic feet			

The works at [illegible] were made under the [illegible] [illegible] and cost, exclusive of the [illegible] apparatus, and a [illegible] of Cable £7886. 0. 0

[illegible]

[illegible] with that at [illegible], the [illegible] [illegible] [illegible] is [illegible] to [illegible]

of 10½ feet with the standard di-
mensions in width, the tank rests
upon blocks; which have been sunk
to a depth of 13 feet. In design
of the structure, thickness of ar-
rangement, attention to the appropriate
[illegible] and general arrangement
of its parts, it is in no way [illegible]
[illegible] the [illegible] and desired
Blocks [illegible] have [illegible]
[illegible] in the [illegible]
[illegible]

The whole of the tank is built
of [illegible] bricks, and
considering the whole, of the [illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible] with great
advantage.

[illegible] that
[illegible]

[illegible] used [illegible]
[illegible]

2 parts of Earth Lime
1 " of Soorkee

The total [illegible]
[illegible]
[illegible] in the [illegible] Tank

	Const. Work not [illegible] supplied materials	Material [illegible] Bricks [illegible] of sizes	[illegible] Earth Lime	Expenditure [illegible]
Masonry	331105	24114	2483287	110369, 66154

Masonry of all [illegible] including Plaster	15 11 6	per 100 Cubic feet
Metalling	5 2 8	— do —

[illegible] Tanks were built under the [illegible] [illegible] of the Regulating Apparatus which has cost the [illegible] Company Rupees 65526. 6. 9¼.–

The [illegible] Falls

The dam [illegible] [illegible] [illegible] as to the [illegible] [illegible] [illegible] wall [illegible] a depth of 26 feet [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] wall [illegible] [illegible] depth [illegible] 12 feet without the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] arrangements [illegible] [illegible] the dam [illegible] the works [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] the foundation [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] sand [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] been used at this [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

not at hand, and it was considered that a platform resting upon the heads of piles, driven a depth of 12 feet and at close intervals, would have been sufficient for the stable support of the superstructure; a slight settlement however took place within 6

6 [illegible] [illegible] [illegible] [illegible] [illegible] completion, showing itself in a [illegible] [illegible] [illegible] about 35 feet [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] foundations, considering that it would [illegible] [illegible] [illegible] [illegible] to remove [illegible] [illegible] the following plan [illegible] [illegible] the [illegible] [illegible] which [illegible] [illegible] [illegible] [illegible] [illegible]

most diligent method [illegible] [illegible]-ation I give you an extract from my memorandum addressed to the Engineer [illegible], on his [illegible] that he doubted the possibility with the means in his possession, of extracting the piling which had [illegible] [illegible] [illegible] across [illegible] fractures and was pulled down and removed for the purpose of re-building it.

Extract from Memorandum No 119 dated [illegible] December 183[illegible].

1st [illegible] the [illegible] [illegible] [illegible] [illegible] present.

2nd [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] sheet piling [illegible] distance of [illegible] feet from the [illegible] [illegible] [illegible] [illegible] in the following diagram.

Diag CXIII

3rd When the [illegible] [illegible] is completed, the soil between it and the [illegible] of the wall [illegible] dug out as deeply as [illegible] [illegible] [illegible] space so dug out [illegible] is filled in with rubble masonry with [illegible] [illegible] [illegible] [illegible] is [illegible] be done [illegible] [illegible] [illegible] in [illegible] [illegible] [illegible]

x [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

arising from the soil & if there is any inattention on this point and the foundations of the walls are left bare and exposed on long spells, the [illegible] of the wall may fall forward. To prevent any possibility of such a catastrophe, every care is always taken to remove the earth from the rear of the superstructure so as to relieve the walls from thrust as much as possible.

The crack at the extreme end of the [illegible] the settlement having taken place apparently at "a" in the above diagram, did not exceed a ½ of an inch, but as this particular part of the work is exposed to all the violence of the current & flow of the [illegible] which occurred, [illegible] not have taken place at a worse point.

The massive parts of the foundations, are flooring of the Drainage [illegible], are built with blocks of kunkur, the rest, including ~~including~~ the superstructure, have entirely been constructed of well burnt bricks of the standard size 12"×6"×3" as made in the regular native brick kiln. The mortar which has been used is made of the following ingredients.

pure kunkur Lime

The quantity of material used, and the rates of the work were as follows

	Content of Work		Materials Expended	
	Cubic feet of masonry	Cubic feet of plaster	Bricks	Kunkur lime
Masonry	304,686	24,114	2,286,645	132,443

Masonry and sorts including plaster 13 7 3 per 100 cubic ft.
Plastering 7 5 7 — do —

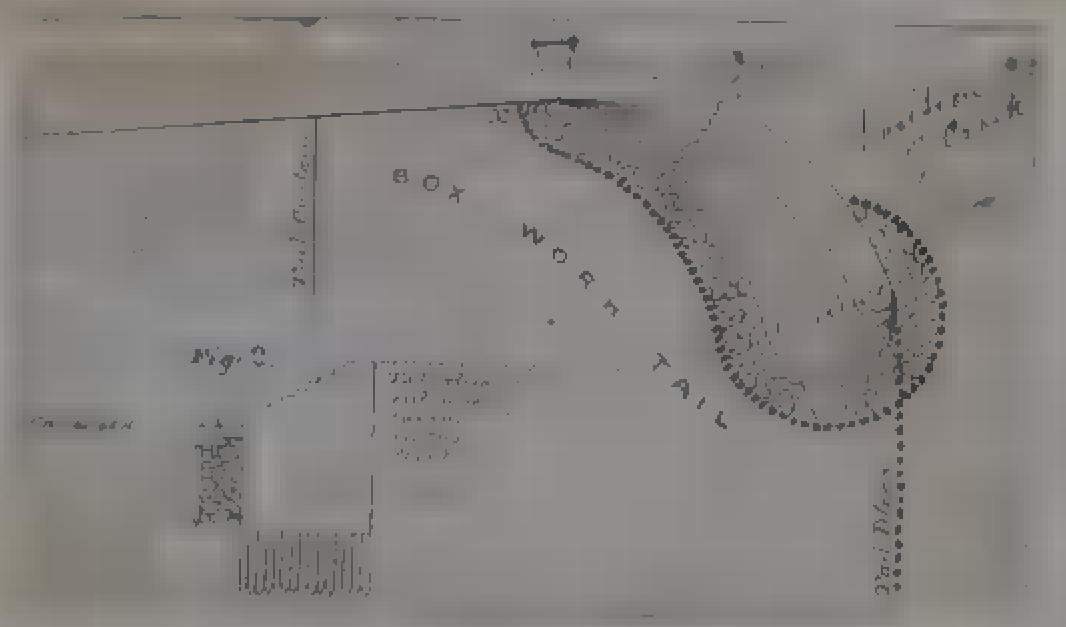
most distinct method of plan-
-ation I here give an extract
from my Memorandum ad-
-dressed to the Engineer [illegible],
on his reporting that he doubted
the possibility with the means
in his possession, of extracting
the piling which had been driven
below the masonry of the hun-
-dred [illegible] was pulled down and
removed for the purpose of re-
-building it.

Extract from Memorandum No 119
dated 24th December 183[illegible].

1st Let the wall stand as
it is at present.

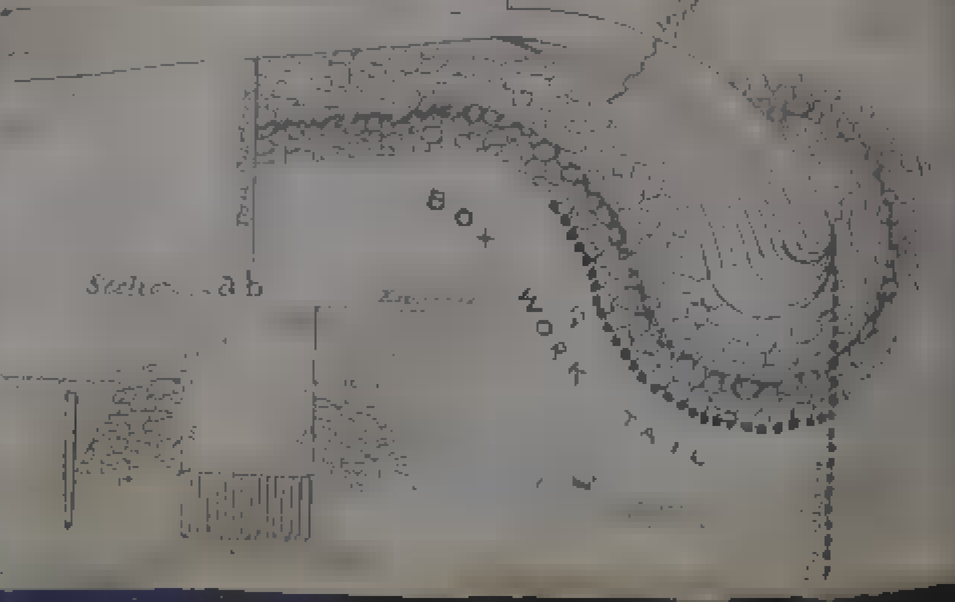
2nd [illegible] a [illegible] of [illegible]
[illegible] sheet piling at a
distance of 6 feet from the out
[illegible] wall as shown in the
following diagram.

Diag. CXIII



3rd [illegible] the [illegible] is
completed the soil [illegible]
[illegible] the [illegible]
[illegible] may be dug
[illegible] and the space
[illegible] is filled in
[illegible] masonry with
[illegible]
[illegible]
[illegible]

*[illegible]



remaining from the end a. If there is any inattention on this point and the foundation of the walls are left bare and exposed in long lines, the substructure of the wall may fall forward. To prevent any possibility of such a catastrophe, Mr. [illegible] is allowed to remove the earth from the rear of the superstructure, so as to relieve the walls from thrust as much as possible.

The crack at the extreme end of the [illegible] (the settlement having taken place apparently at "A" in the above diagram) does not exceed 1/2 a quarter inch; but as this particular part of the work is exposed to all the violence of the current, a flaw of this sort would occur, and not have taken place at a worse point.

The massive parts of the foundations and floorings of the Dasna falls, are built with blocks of kunkur, the rest, including ~~[illegible]~~ the superstructure has been entirely constructed of newly burnt bricks of the standard size 12×6×3" as made in the [illegible] or native brick kiln. The lime which has been used is made of the following ingredients.

pure Kunkur Lime

The quantity of material used, and the rates of the work were as follows

	Content of Work		Materials Expended		
	Cubic feet of masonry	Cubic feet of plaster	Bricks	Kunkur Lime	
Masonry	301,886	24,114	3,866,645	132,443	–

Masonry of all sorts including Plaster	13 7 3	per 100 Cubic feet
Pitching	7 5 7	– do –

This work also had the advantage of the constant attendance of an European Officer who lived on the spot during the whole of its construction and who saw the work in its daily progress. It was begun and completed under the superintendence of Mr Read and the cost, exclusive of regulating apparatus which was debited to the Canal Company [illegible] Sub 3rd, 12[illegible].

The above gives as concise a description as possible of the falls with a drop of eight feet, comprised in Section II. and [illegible] [illegible] relative to the [illegible] of the main Canal, being about [illegible] of the Bolundshahur Branch.

III. Falls with a Drop of 5 feet.

This Section includes two descents near the village of Phulera and Teneza, which are consequent on the general depression of the surface of the country, at the water shed between the Hindun and [illegible]. They are situated at the 149th and 164th miles of the course of the main Canal. The Meerut [illegible] Bridge with a waterway of 60 feet in breadth lies at a point Eight miles on the upstream side of these descents, and 3 miles below them is the Kuptowr Bridge, a work on the same dimensions as that at Meerut Bridge.

To

The [illegible] Branch head which abstracts from the main Canal 220 cubic feet per second is situated 30 miles above the falls, and the next head which is of the same [illegible] as that at [illegible] lies between the [illegible] a point 3 miles below the first descent.—

From the [illegible] Falls, which terminates the last series, to the head [illegible] at [illegible] [illegible] the present [illegible] distance is equal to 43 miles. The [illegible] and [illegible] falls are separated by a distance of [illegible] miles.

[illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] I have [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the falls [illegible] [illegible] [illegible] [illegible] the [illegible] adjustment of the branch heads and that of the [illegible] [illegible] [illegible] [illegible] [illegible] which [illegible] [illegible] at [illegible] [illegible] [illegible] regulating the supply ~~[illegible]~~ ~~[illegible]~~ [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] design is similar to that which has been before described. The [illegible] of the [illegible] has been reduced to 101 feet [illegible] [illegible] the [illegible] [illegible] of Channel [illegible] divided into 2 [illegible] of [illegible] each, each [illegible] its [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

... [illegible] ... have been adapted to the locality in which they are built. Those called the Falls at [illegible] ... passage from [illegible] part of these [illegible] ... The locks [illegible] are about to [illegible], are as follows:

[illegible] 100 feet in length.

[illegible] 140 [illegible]

[illegible] 164 [illegible]

[illegible] Rubra Falls [illegible] XL

[illegible] as will be understood from the preceding [illegible] a [illegible] to locks [illegible] into [illegible] [illegible] [illegible] passage of 3 feet wide; the [illegible] are [illegible] over [illegible], as follows: the [illegible] into chambers of [illegible] feet in width, and the [illegible] with [illegible] so that in case [illegible] chamber may be [illegible] the [illegible] to the different parts of the works by means of [illegible] and [illegible] passages on [illegible] [illegible] in the [illegible] of the [illegible] and the [illegible] [illegible] in the [illegible] [illegible] CVI.

The foundation walls [illegible] and [illegible] on the [illegible] [illegible] to

to a depth of 15 feet. In March the sediments and [illegible] were found [illegible] laid at a depth of 13 feet above the [illegible].

The abundance of Kunkur Quarries of which are numerous in both the Moradabad and Bijnour Districts enabled us to dispense with piles and introduce [illegible] which would [illegible] have been [illegible] difficult. The protection [illegible] [illegible] to the upper and lower [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] [illegible] with the completion of the [illegible] and those parts of the [illegible] which it was [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] built in Kunkur [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The mortar consisted of the following proportions.

1 Part of Kunkur Lime to
20" of White Stone Lime

In excavation of the foundations of the [illegible] which [illegible] parallel to the [illegible] a falls, beds of [illegible] had to be cut through and a [illegible] [illegible] locally called "Kuprela" [illegible] [illegible] the [illegible] and [illegible] the foundation [illegible] itself [illegible]

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ch. ii. part iii

soil was of the best description that had been met with in founding works of this sort.– And water was sufficient [illegible] to the [illegible] to admit of its free use in the works.–

The quantity of material used, and the rates for building were as follows:–

	Contents of Work		Materials expended			
	Cubic feet of Masonry	Square feet of Plaster	3 Inch Bricks	[illegible]	Stone Lime [illegible]	Kunkur Lime [illegible]
Masonry	174375	43274	224141	128802	117½	48318

Rates.–	Arch masonry	12	per 100 Cubic feet
	Other do	10 2 8	" "
	Plastering	2 7 9¼	per 100 Square feet
	Whitewashing	2	" "
	[illegible]	15	each
	Windlasses	20	—

The [illegible] works were begun and completed under the superintendence of [illegible] at a Cost

Masonry work	17404	11	1
Protective works	1630	12	10
Wood work	240	..	..
[illegible]	1000	..	..
Total Company's Rupees	20275	7	11

[illegible] nra Falls

This is a [illegible] fall of the [illegible], with [illegible] elevations [illegible] the foundations [illegible] the [illegible] of [illegible] to that of the Canal [illegible]. The [illegible] or upper [illegible] of the [illegible] falls are 15 feet in depth, and consist of a plain line of [illegible] masonry 6½ feet wide.– The [illegible] foundations [illegible] on [illegible] sunk to a depth of 15½ feet.

[illegible] has been used [illegible] falls, it may [illegible] the [illegible] be considered the staple material

material of the building.

The cement is [illegible] the following ingredients

1 Part of Kunkur Lime to
1/20th of White Stone Lime

The quantity of material used and the rates of building are shown in the following table.

	Content of Work: Cubic feet of masonry	Content of Work: Square feet of Plaster	Materials Expended: 3 Inch Bricks	Materials Expended: Block Kunkur [illegible]	Materials Expended: Stone Lime [illegible]	Materials Expended: Kunkur Lime [illegible]
Masonry	186063	45059	276304	122790	198	52417

Rates	Arch masonry	1[illegible]			per 100 Cubic feet
	Other do	[illegible]	12	3	do
	Plastering	2	8	2½	per 100 Square feet
	[illegible]	2			do
	[illegible]	15			Each
	[illegible]	30			do

The cost [illegible] work [illegible]
equally [illegible] of the [illegible]
and the [illegible]
[illegible] the protective works, but
[illegible]
masses of kunkur [illegible]
[illegible]
[illegible]

The above table was drawn and compiled under the superintendence of [illegible]

Masonry	19042 2 9
Protective works	1604 12 [illegible]
Wood work	240
[illegible]	1000

Total Company's Rupees 21886 15 7

This brings us to a consideration of the subject of all the minor descents which have been described as existing on the Ganges and Eastern Jumna Canal [illegible]
[illegible]
[illegible] information [illegible]

[illegible]

will be satisfactory, however, to append a table of the calculated values of the falls above described in connection with their theoretical discharge.-

In drawing up this table I have allowed the obstructions from piers or aprons to cancel the value of initial velocity: the figures, therefore, actually exhibit the depths due to water pouring over weirs from a still basin. My calculations are based on the formula for this species of discharge, because both the aprons and initial velocity were necessarily variable quantities depending on the volume of water discharged as they were [illegible]. Their effects were always [illegible] tendency to decrease rather than to add to the height or depth of water on the sill or [illegible] of the [illegible].

The falls on the Eastern Jumna Canal, which are 50 feet in width, [illegible] of 26 and 2 of 15 feet each, carry over them with an average depth of 3 feet of water; the maximum may be considered as 3½ feet although occasionally in the rainy months the depth rises as high as 3¾; the actual discharge of the above figures and with the reductions above alluded to, is as follows.-

Width of waste-way	Depth of water on sill	Discharge in cubic feet per second
50 feet	3·75 feet	1930·375
60 feet	3·5 "	1112·65
70 feet	3·[illegible] "	685·30

Supposing [illegible] always [illegible]

the

then only for short periods, the depth of water upon the sills of the Eastern Jumna Canal falls is 3 feet. it is frequently and generally in the lower divisions under this depth. —

As the action upon the brick work and flooring of the above works (with the design and construction of which I was ~~acquainted~~ familiar) was well known, and could after an experience of 12 years be well appreciated, I considered that in the Ganges Canal falls, we might with perfect security increase the above depth upon the sills to five feet, [illegible] as far as ten; but I adopted the maximum quantity, as that which we might most satisfactorily approximate. — The disposition of bricks in the drops of such works as above described is dependent on other causes than ~~[illegible]~~ the discharge with [illegible] [illegible] [illegible] before alluded to the discharge of the Ganges. When the [illegible] [illegible] of additional supply to the [illegible] [illegible] from the [illegible] [illegible] Heads. — The massiveness of foundations is dependent on the nature of the soil, [illegible] most cases is sand; it was not thought worth while, however, to alter in their minor details these plans and received dimensions for the purpose of adapting existing works to their own particular locality.

The following table will show the amount of the ordinary volume of water at the head of each

each of the Falls and the amount of discharge, supposing that the depth of water on the sill or upper platform of the overfall is equal to 5 feet. The formula used is that for discharges of water from reservoirs over side weirs or open Sluices.—

$$\frac{LD \times \sqrt{D} \times 5.1 \times 2}{3} = \text{Discharge in Cubic feet per second}$$

	Miles from Reservoir	Breadth of waterway	Depth of water on the Falls	Approximate discharge in cubic feet per second	Theoretical discharge in cubic feet per second
Hoffruggen Falls	24	200	5	6667·5	7582
[illegible] "	31	200	5	6585·	7582
[illegible]	42	200	5	6502·5	7582
[illegible]	48	200	5	6420·	7582
[illegible]	55	200	5	5097·5	7582
[illegible]	68	150	5	5015·	5686·5
[illegible]	[illegible]	150	5	4932·5	5686·5
[illegible]	106	150	5	4850	5686·5
[illegible]	[illegible]	100	5	3994	3791·
[illegible]	[illegible]	100	5	[illegible]	3791·

The amount of volume [illegible] in the 4th column is due to a deduction of about [illegible] cubic feet a second, for water supplied to the navigable cut, which leaves the main Canal above the falls. This deduction may be considered constant, as the navigable channel can only be kept in an efficient state by passing a current through it.

CHAPTER, III.

Works of Communication

The [illegible] and the Bridges forming part of the works of the [illegible] those situated at the Terminal heads at [illegible], and at the [illegible] Bulandshahr [illegible] Branches, together with those connected with the Falls and the different buildings for crossing the Canal at the other [illegible] works on the Ganges and Jumna Rivers are [illegible] in this chapter. [illegible] bridges [illegible] referring to the [illegible] the description of the above mentioned [illegible] that is the works of which they form [illegible] parts.

On the [illegible] ~~[illegible]~~, [illegible] the works [illegible] described as in preceding chapters [illegible] a position which it naturally occupies in connection ~~[illegible]~~ with Bridges [illegible] Generally [illegible] the Ganges Canal works particularly [illegible] of [illegible] a most [illegible] [illegible] in the [illegible] of the works. It was [illegible] accordingly [illegible] [illegible] Under this view, the present [illegible]

[illegible]

be divided ~~itself~~ into the following sections:-

I.. Centerings

II.. Bridges between the Head of the Canal and Roorkee

III.. Bridges between Roorkee and the Nanoon Fork

IV.. Bridges on the Terminal Lines between the Nanoon Fork and the Terminal works

A. Cawnpoor Line

B.. Etawah Line

V.. Bridges on the Branches

I. Centerings

These may be separated into two classes; the 1st consisting of timber, of the method usually adopted in Europe; the 2nd, of earth, or a combination of earth with brickwork, as common in India. On the Ganges Canal works the above classes may be thus described. –

Class I. A. Centerings used at the Myapoor head works

B.. Centerings used in Bridges of 35 feet span in the Rajbuha works

C. Centerings used on the high Level of the Canal. –

D.. Centerings used at the Solani Aqueduct, and at the Falls in the Khadir or Northern Division of the works

Class II A.. Simple Centerings of Earth

B.. Compound Centerings of Earth, and Ribs composed of a rigid material. –

Bridges

Before proceeding with a description of the above, I may remark, that the rule adopted in all cases, ~~[illegible]~~ was to relieve the arch slightly as soon after the keying was effected as possible; to continue this relief gradually and according to the circumstances of the particular case but invariably to have the centering removed entirely within a month after the arch was keyed.

Class I

A. vide ~~Plan~~ Sheet 1 Plate XLII-4 of the Atlas. This design was put in practice throughout the works at the Canal Head at Myapoor. With Centerings of this description, the arches of the Regulating Bridges of the Bochna head and of the Small bridge that lies on the Mile of that name above the head were built. The Span is 20 feet, and the ribs (placed 4 feet apart) were supported on temporary pedestals made of Brick and Mud, resting above upon the piers. The ribs rested on a striking apparatus consisting of the usual double wedge or of pyramidal shaped bolts which were supported by the above pedestals. The results appear to have been satisfactory, although I have no record of the action upon the Arches on the removal of the Centering. The Arches are built in 3 concentric rings 6 inches in depth each, and are consequently

better

[Margin note: ^ Ten ~~six~~ in number]

without voussoir: the curve is a segment with a rise equal to 4 feet, or to $\frac{1}{5}$th of the span. Newly made bricks 12" × 6" × 2½" were the material used.

B. vide Sheet 2, Plate LXII of the Atlas. The whole of the 55 feet span arches in the Khadir and Northern Division have been built with this species of centering. Its great merits consists in its being made with the Kurris or staple rafter brought from the Sewalik Forests, the Kurris not being pierced or injured by tenon and mortise, and, consequently, by their being available after use for other purposes. The design is an excellent and a most economical one, it is due to Lieut. Yule of the Bengal Engineers.

The method of fixing the ribs in position, was here (allowing for the excess of width) much the same as in the former case, in addition to the flank pedestals there were 3 intermediate ones, upon which the striking apparatus similar to that used at the Myapoor [illegible] rested, and the process of striking was performed on the plan there explained. These arches although exhibiting on the Extrados an elliptical curve, are all perfect segments of circles, with the voussoirs of brick courses radiating to the centre; the construction in this respect is shown in Fig 3 Sheet 2 Plate LXII. They are built with large bricks 12" × 6" × 2½", the thickness of the brick being in some cases 3 inches. In the volume of Tables, p. [illegible]

All returns will be found of the Amount of Subsidence

of the crown head of the centering following the removal of the cen-terings. During the construction [illegible] aware that any settlement was observed, and the [illegible] bridges of the Solani Aqueduct which were built with these cen-terings, the upstream one by Mr Fardley, and the downstream one by [illegible] [illegible] are two of the most satisfactory works of this sort that have been completed.

C. [illegible], Fig. 3. Plate LXII

These were designed by [illegible] [illegible] Engineer who had charge of the 2nd Division in which the roadway bridges next to those [illegible] are included. The Centering was only used on six occasions; the cost of carriage from one spot to another was found to be very great [illegible] delay [illegible] [illegible] use was [illegible] [illegible] after the completion of the six Bridges at Munglour, [illegible] Dimat, Jo-gulpoor, Belra and Bhopa, [illegible] the woodwork was converted to other purposes, and the use of [illegible] centerings was adopted. The method of fixing the ribs and of striking the centerings needs no particular description, generally speaking it was similar to that laid down for the guidance of Executive Officers; and practised in the former cases. The Munglour Bridge arches were in all their parts elliptical, their brick courses were laid in concen-tric from the 5 centres on which the intrados of the other bridges of this description were described; this is a striking example of this species

of [illegible] and as it [illegible] happened, the [illegible] in [illegible] were [illegible] from the [illegible] [illegible] a lake [illegible] — [illegible] bricks used were 15" × 6" × 3" and [illegible] [illegible] [illegible] out for the purpose [illegible] [illegible] of [illegible] of the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] be found in the Table.

D. [illegible] Sheets 7 to 9, Plate **XXVII**

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] a detailed description [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the Aqueduct [illegible] [illegible] it will be sufficient [illegible] observe that the [illegible] [illegible] ~~[illegible]~~ Timber vessels [illegible] that the [illegible] was [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible], the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] consisted of [illegible] [illegible] the [illegible] [illegible] [illegible] country [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] but [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and to equalize the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible]

[illegible] II.

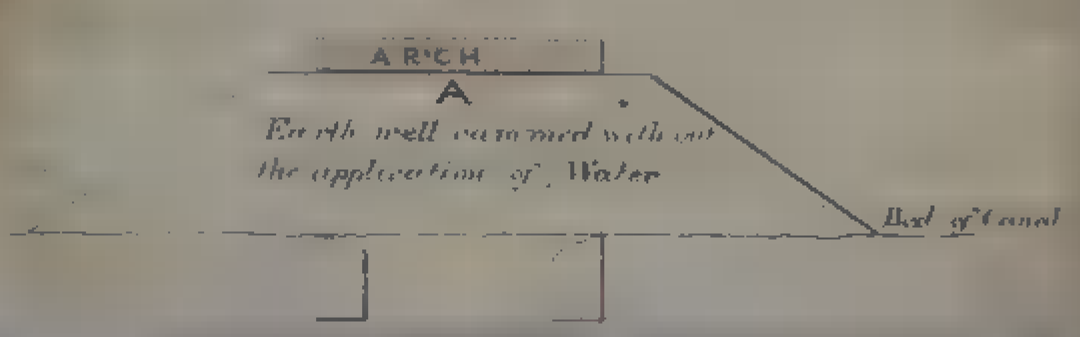
A — [illegible] [illegible] the [illegible] [illegible] [illegible] 47 [illegible]

the 110th mile, was built on con-
[illegible] of Earth only, the design of
which will be best shewn in a Dia-
gram representing a bridge on
its transverse vertical section thro'
the crown of the Arch.

[illegible]

B.74

Diag: CX



With the completion of the 8 bridges
at the lower extremity of the line
on which the system of [illegible] was
[illegible] [illegible] [illegible] [illegible]
[illegible] to the construction of
these [illegible] having been [illegible]
and excavated, it was indeed
necessary from the sandy nature
of the soil [illegible] [illegible]
[illegible] [illegible] excavation
[illegible] abutments [illegible]
[illegible] [illegible] accidents [illegible] the
subsidence of the [illegible], it was a
matter of the utmost importance
to excavate in long slopes, [illegible]
the [illegible] [illegible] either
the foundations of the piers and
abutments, or of the [illegible] walls
[illegible] [illegible] [illegible]
gradual process of filling in the
[illegible] [illegible] [illegible]
being met by a corresponding [illegible]
in the thickness of the earth.
In other cases [illegible] [illegible] the
sand on which the foundation walls
were laid was pure sand, the [illegible]
of

of the area on which the masonry rested, was one crater or hole, and on the completion of the above walls the soil in the vicinity was necessarily [illegible] possible, to [illegible] therefore, were not built previously to the building of the centerings, nor could the economy which will be noticed frequently of constructing the Centerings on the natural ground be adopted. The course of proceeding in all the above mentioned cases was as follows: To complete the excavation on the canal, to finish the substructure of the bridge in all its parts (with [illegible] drawings) up to the [illegible] of the [illegible] blocks; to fill the bay with earth as shown in the above diagram, to form the upper part of the [illegible] to the desired curve and upon it to build the arch.

All the results of our leading trials with these centerings had a very material influence on the design for the centerings of the Aqueduct. I must at the expense of [illegible] detail, explain the circumstances under which this influence was exerted. The [illegible] consists of 18 arches of 50 feet span each, the width 192 feet being divided in the centre so that the arches might be constructed separately in widths of 96 feet each. To make [illegible] centerings for such an extent of [illegible] would be very expensive [illegible], and at the period in question was considered to be a work of great time and labor; in the early part of our proceedings therein, I had

[illegible]

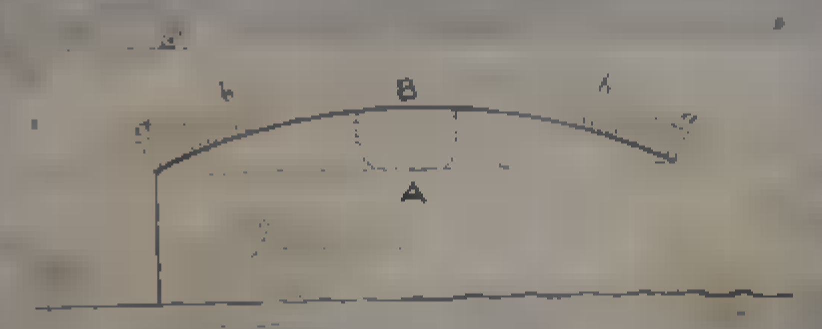
intended to adopt earthen centering similar to those in common use by the natives, and the only question that arose was whether to make them of simple earth, or else make them of brick walls and earth. So far as economy was concerned the saving of expenditure in using this simple species of centering would have been enormous, and although there were inconveniences in connection with the total stoppage of the waterway, which would have to be removed by slowing the completion of the arches, and the removal of the centering during three months in the year when no floods could be expected, the plan had great advantages in these respects, and it may be easily supposed. Before arriving at any conclusions, however, it was advisable to see the results of the earthen centerings which were at that time in process of construction below Roorkee, and although the weight of the arches of the 50 feet span bridges was less than that of those of the aqueduct, we should gain some practical information which might be obtained. The results were sufficiently unsatisfactory to lead me to discard this species of centering for the aqueduct arch, and I could devise no satisfactory method either by brick piles or by transverse walls of avoiding the evils that were inherent in centerings of this description, without adopting in extenso the native method of building a rigid centering and allowing it to remain until the masonry of the arch was

[illegible]

indurated

To explain the objections to the earth's embankments as inappropriate if not to be fatal to arches intended for the support of large bodies of constantly running water, I will in ~~another~~ diagram shew in Elevation that which has been before described in cross section.

Fig. CXI.



A represents the earth of which the transverse section is shown with diagram CX. B represents the arch in the construction of which the brick courses are laid from the skewbacks a a inwards towards b b. Now in building the arches it was universally observed that when ~~[illegible]~~ the courses of the brickwork had reached beyond the point ~~of~~ of equilibrium and immediately when the weight of the material began to act on the compressible centering; ~~[illegible]~~ there was a tendency to downward action on the haunches, one of them at the skew-back the other about 6 feet from it, at those points marked a and b in the above Drawing; here there were

were distinct separations in the brick work increasing as the arch advanced towards the centre. The maximum amount of opening as observed not exceeding 1 inch on the extrados, at the period when the final measure of keying took place. During the operation of keying, and immediately afterwards on the earth being removed from the intrados of the [illegible], the separations almost disappeared, but although this closing was to all intents and purposes as perfectly effected as it could well be, the line of separation was distinctly traceable again when [illegible] the brick on its extrados and I considered it advisable in every case to [illegible] a week or ten days over the [illegible] separation although I have [illegible] that the continued [illegible] would restore the masonry to its original integrity.

Diag: CXII.

However unimportant such a defect might be in arches for ordinary purposes I concluded that for an Aqueduct carrying water it was quite inadmissible, the aqueduct arches moreover being considerably heavier, would in all probability be attended by separations [illegible]

[illegible] more [illegible] character, [illegible]
Earth in centerings for the aqueduct thus far, was at once abandoned, and at this place the design which has been since carried out, and which was [illegible] of [illegible] was suggested by Captain [illegible] the [illegible] Engineer of the work, [illegible] may [illegible] from any further [illegible] to the subject.

[illegible] through which was built by the 5th division were the experimental [illegible] of the [illegible] that, [illegible] to their own [illegible] duties, they [illegible] daily [illegible] the [illegible] of [illegible] both in time & [illegible] expenditure. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in other cases. ~~[illegible]~~

[illegible] to remove the earth from that part of the centering immediately under the crown, or within the lines marked in the diagram, after the [illegible], it will be understood that that part of the centering lying to the right and left is easily got out of [illegible] from its [illegible] position, the laborers are able to dispose of the earth, and throw it on the lower levels with little waste of time, and with little expenditure.

of [illegible] [illegible] —

The arches in this drive way, with the exception of the arches of the 3 tiers (as described in the following letter) which have been made with [illegible] rubbed [illegible] built in which of new bricks 12" x 6" x 3" with excellent Mortar, used as sparingly as possible, and semifluid, whilst the bricks themselves had been pre=viously to their being laid in the work well soaked in water.

B. In the Centering [illegible] which we have [illegible] [illegible] and as far as can be [illegible] equally [illegible] to all the [illegible] in which the [illegible] is laid [illegible] we are now about to describe we have [illegible] [illegible] [illegible] material, and in this respect [illegible] the [illegible] it has the advantages [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] is [illegible], and with proper management of main-taining a sufficient equilibrium in its parts, to prevent irregularities of depression. This system of Centering has been used in the whole of the works for the [illegible] Great [illegible], and has been practised with more [illegible] [illegible] in all the arches where the span of the [illegible] was [illegible] from 25 to [illegible] feet in width. —

The following drawings will show the method of con-struction adopted in this par-ticular case, where the [illegible] [illegible] and the [illegible] are [illegible] [illegible] support in the centering

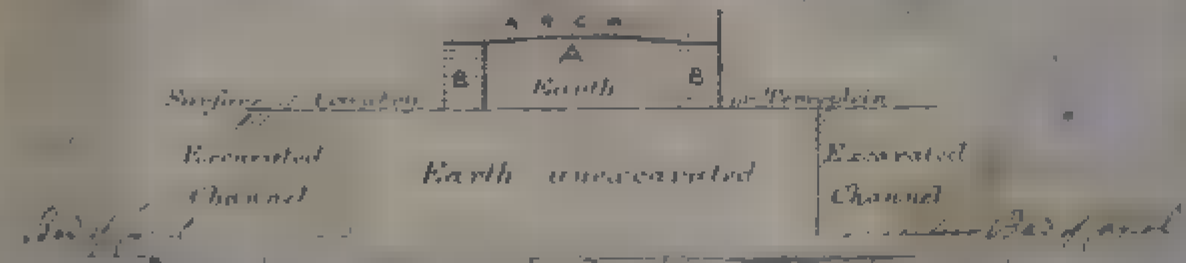
of

the lateral friction [illegible] in many cases consists of the ground upon which the Arch is designed.

Diag: CXIII

Transverse Section of Crown of Arch

B.77



A represents the earthen [illegible] supported on each side by the walls BB built of brick with Roman cement, constructed in such a way that it can easily be separated.

Elevations showing the above on different methods of construction which the Arch is intended to facilitate the removal of the bricks [illegible] the crown of the Arch [illegible] as possible after it has been keyed.

Diag. CXIV

In both these cases it will be observed that the piers have been built with the natural soil between them unexcavated. The inner part of their foundations at a x being prepared for after construction [illegible] of the floor [illegible] and [illegible] walls when the [illegible] and the earth which have been left for their support have been removed. The artificial fou-

Fig. P. P. 209
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portions of these centerings [?] were, are segments of circles corresponding in shape with those of the arch which is to be built upon them. It has been considered sufficient to give two examples of this species of centering, the brickwork having been built in a variety of ways all intended as before said to facilitate its removal; the omission of every alternate brick in the deepest part of the segment was found to be well adapted to the object in view, but in all cases, the course that was followed in the plan and its centerings, of settling the whole of that portion of the centering lying directly under the crown immediately after the arch was keyed, and afterwards drawing as quickly as possible from the centre to the sides was strictly attended to.

It will be observed in Diagram CXIII that the earthen portion of the centering is slightly convex [?], technically cambered [?], a device that was found to be of great advantage in cases where the width of arch exceeded 21 feet - in such cases, there was an inclination in the brick work to settle unequally from the compressibility of the earth, an evil that appeared to increase directly as the distance from the lateral ribs. In very wide bridges therefore, an intermediate brick rib [illegible] might perhaps with advantage be used, so as to secure uniformity in the settlement during the [illegible] while the arch was building. It is evident that [illegible]

lie action of compressing and rigid material which this expense of centering involves, the immediate relief of the arch is indispensable, this however is so easily managed that with proper care no delay ought to take place, and there can be no doubt that the curve is ~~[illegible]~~ better maintained in cases where centerings of this sort have been used, ~~[illegible]~~ than in arches constructed on plans which are [illegible] by brick ribs which have ~~[illegible]~~ a greater degree of settlement before they were [illegible].

The process that succeeds the removal of the centerings is to excavate the material or soil upon which they are built, and so to clean out the canal channel. The culverts and facings of the banks are then built with as little delay as possible. By adopting this cheap plan of centering the whole of the bridges thereon are dispensed ~~is~~ one of the elements which constitutes the standard as described in the leading rule of construction, that is to say, the arch is allowed to exert its thrust upon the abutments before the lower fulcrum is fixed. —

With the exception of the few bridges on which [illegible] king is used, the arches are built of brick [illegible] before described with the usual care given in the [illegible] use of water. In every case [illegible] is [illegible] as [illegible] of [illegible] [illegible] [illegible] that [illegible]

[illegible]

of which I have no accurate record)
Three bridges ([illegible] feet span) the settlement after removal of the centering and after the centerings are removed, has led to a very slight separation of voussoirs at a point ~~at~~ from 6 to 12 courses of brick from the skewback; this separation is to be detected along the whole line [illegible], while on the face of the arch underneath or on the intrados where the hinge of this movement takes place, no trace whatever of separation is to be observed. In all cases, (and exhibited at an early period when the superstructure was hurried forward) subsequent settlement is shown by cracking in the parapets.—

The arches of the Cranford and Cutter Super-passages were built upon centerings of a similar plan to that which I have described, the extraordinary width of the arches, in the former case 210 and in the latter 310 feet, calls for peculiar care in making the earth as incompressible as possible. Arch ribs were limited to the up and down stream ends of the works: and the results have been very satisfactory; the effect upon the haunches after the removal of the centerings however was similar to that which has hitherto been remarked upon.—

In concluding this section I may draw attention to a plan of centerings which was adopted by Lieut. [illegible] of the Engineers when building the Arches (25 feet span) of the

Earth

vault and Cistern Tanks.– The position of the rays at these tanks, as will be observed by reference to the plan, is most unusually inclined from the absolute want of lead in the buildings, when they are increased in extent beyond the usual limit. The locality also is especially inconvenient for the subsequent removal of the Earth and the cost attending upon the whole of the operation is unusual.– During the construction of works of this sort, some centering (for which cupla is taken as ordinary in the present used) was very requisite; wood of all the smaller descriptions, such as Kurrees, Sees and Hullas was not at hand. I thought I would, without cutting up any of the wood especially for this purpose, so used it in connection with brick and mud supports for a superstructure of Cupla laid closely together, and formed on its upper surface in the shape of the required curve; upon this as a centering perfect success attended the erection of the tanks, which were completed very satisfactorily. And the cost of the centering was merely the labor of building and pulling down, and both the wood and cupla were uninjured and available for their proper purposes.– I consider this to have been one of the best of many applications of simple means to useful purposes that are here ~~existing~~ exhibited in these works, [redacted]

914

[redacted]. Although in none of the Centerings that was used, even in cases where the haunches were loaded previously to the crown, did we escape from settlement, it was quite pronounced in the arches that were built with the frame-work centering as described under the head of Class II A. In these cases the deformation assumed the character of an absolute sinking at the haunches, until the keying of the arch partially eliminated it. [redacted]

Of the Timber Centerings described in this Section I should give a preference to that form known as Class I D on account of its adaptation and convenience in use; to which

Truss, Class I B for its economy of timber work. The former being of timbers cut up for the especial purpose are expensive in manufacture, nor are they economical as the pieces are placed in position separately. The latter as [illegible] are made of the [illegible], or [illegible] which is purchased at a small cost, and is available for its original purposes after the [illegible] [illegible] be [illegible] as [illegible], them having to be placed in position in [illegible]asses.

Of the [illegible] placed under Class II. B, is undoubtedly the best in [illegible] of its being composed of a [illegible] of rigid and compressed matter, but in using it, [illegible] must be removed with as little loss of time as possible, so as to prevent its [illegible] homogeneousness [illegible] to the [illegible] [illegible].—

Before commencing on the subject of the 2nd Section of this chapter, it will be convenient to make a few introductory remarks on the general plan of construction in the building of the Bridges.—

The works of this description as designed for the Ganges Canal are built entirely of masonry in the Khadir, whilst the [illegible] over the Rivers and [illegible] [illegible] distant from the [illegible] of the [illegible] connected with the [illegible], the [illegible] predominating have been universally used with cement made of the best [illegible]

of Lime obtained from the calcination of Crystallized Lime Stone collected in the beds of the rivers in the Deyrah Doon and in valleys of the ranges and its branches. In the bridges above Roorkee and as far down as the 95th mile, brick is the staple commodity; below this point both brick and block kunkur have entered largely into the construction of all the works, in many instances brick has only been used in the arches. The [illegible] [illegible] [illegible] made of a great variety of [illegible] and [illegible]; [illegible] within a moderate distance from the Khadir, the use of [illegible] and lime to which [illegible] [illegible] was extended as far as economy would permit. Bricks have been of a very inferior quality, especially that from [illegible], therefore the [illegible] [illegible] lime, after which [illegible] throughout the works [illegible] the [illegible] [illegible] of 130 [illegible] Allygurh, [illegible], [illegible] &c, have [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] was the staple ingredient for the Cement. —

The Bricks which have been made in our own manufactories for the purpose of Bridge building are of the following dimensions

12" × 6" × 3"

12" × 6" × 2½"

The best ~~that have been made~~ are those from the kilns in the neighbourhood of [illegible], they are generally good, however throughout the upper structures

for

as down as the Narora Regulator: below that point the soil becomes affected by (reh) an alkali that appears to deteriorate the earth as [illegible] for brickmaking. This reh is not universal, but its prevalence leads to the necessity of great discrimination in the selection of ground for brick manufacture. It has led to much disappointment and much pecuniary loss. As a rule, I consider that the bricks used in the works below Narora are inferior to those of the upper Districts, and in the Narora Terminal Works, that both the bricks and cement which have been used in the Narora District are ~~[illegible]~~ inferior to others.

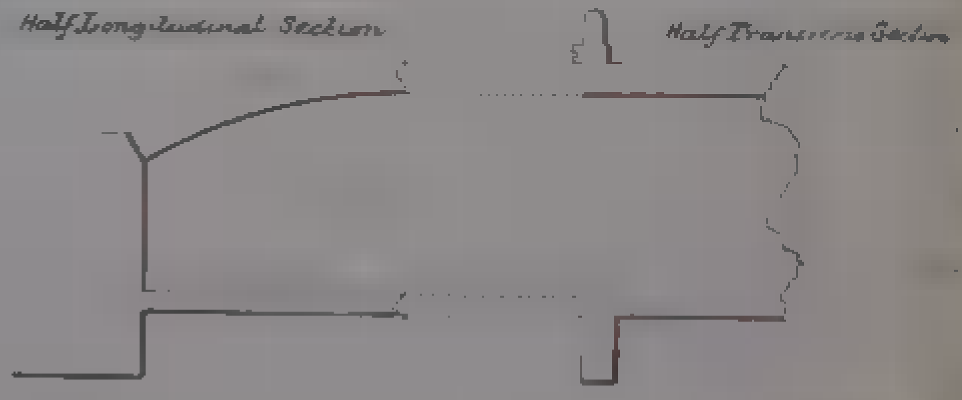
In the Town of Narora itself and in the buildings which are included within the head of the Terminal works, improved administration in the [illegible] early of the material used resulted, I have [illegible] to a great improvement in both the quality of the bricks and of the mortar. [illegible] I consider it better in the latter which by relinquishing as far as it was possible any dependence on purchases of lime from contractors, and by seeing that the lime [illegible] taken from the [illegible] was properly [illegible] the [illegible] [illegible] it was burnt.—

For the design and construction of Bridges I was guided by the following general rules, the leading ones of which may be best explained by a diagram

B 94

1st All Bridges to have floors with Curtains on the [illegible] not only for the purpose of adding strength to the work, but to act as a dam for retaining the levels of the Canal; the Section Longitudinal and Transverse being on the following diagram.

Diag: CXV



In every case, however, there are 3 elements opposed to the thrust of the arch.

1st The abutments and the back soil.

2nd The masonry lining walls & approach.

3rd The floorings and curtains of the bays.

2nd In all cases where the soil in which the foundations were laid ~~[illegible]~~ was sand, [illegible] instructions were to be laid down. In some cases where the ground was hard and of a [illegible] quality, the [illegible] curtains were [illegible] to exceed 10 or be less than [illegible] feet in depth, the maximum measurement being [illegible] pressure on the [illegible] 10 [illegible] of the course [illegible] [illegible].

3rd Where the Canal bed in the vicinity of a bridge was sand or of a light soil, the floorings were to be protected by a line of sheet piling, with heavy masonry laid [illegible] agreeably to the standard plan adopted in the Canal works of these Provinces, the [illegible] [illegible]

as down as the Narora Regulator: below that point the soil becomes affected by (reh) an alkali that appears to deteriorate the earth ~~as~~ ~~[illegible]~~ for brickmaking. This reh is not universal but its prevalence leads to the necessity of great discrimination in the selection of ground for brick manufacture. it has led to much disappointment and much pecuniary loss. As a rule, I consider that the bricks used in the works below Narora are inferior to those of the upper districts, and in the Cawnpore Terminal works that both the bricks and kunkur lime which have been used in the Cawnpore Districts are ~~[illegible]~~ inferior to others.

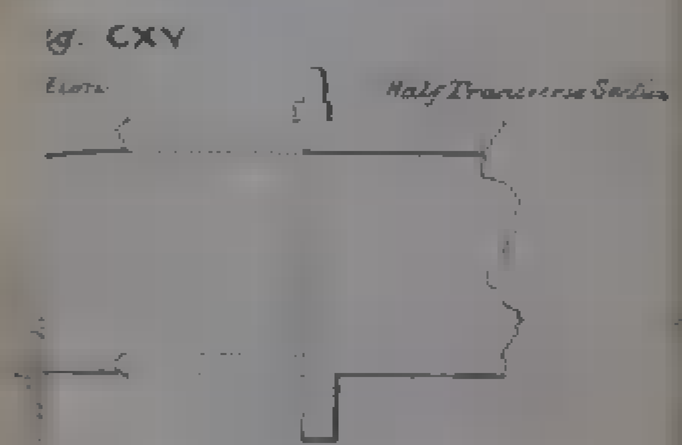
In the Town of Cawnpore itself and in the buildings which are included under the head of the Terminal works, expensive [illegible] alterations in the [illegible] of the material used [illegible], have led to a great improvement in both the quality of the bricks and of the mortar; [illegible] I consider the better [illegible] the latter [illegible] as far as it was possible [illegible] depended on the analysis of lime [illegible], which showed that the lime [illegible] taken from the [illegible] was properly [illegible] the quality [illegible] used —

In the design and construction of bridges I was guided by the following general rules the [illegible] of which [illegible] by a diagram

12

B.94

1st All Bridges to have [illegible] with Curtains on the [illegible] not only for the purpose [illegible] adding strength to the work, but to act as a [illegible] for retaining the levels of the Canal; the Section Longitudinal and Transverse being on the following design.

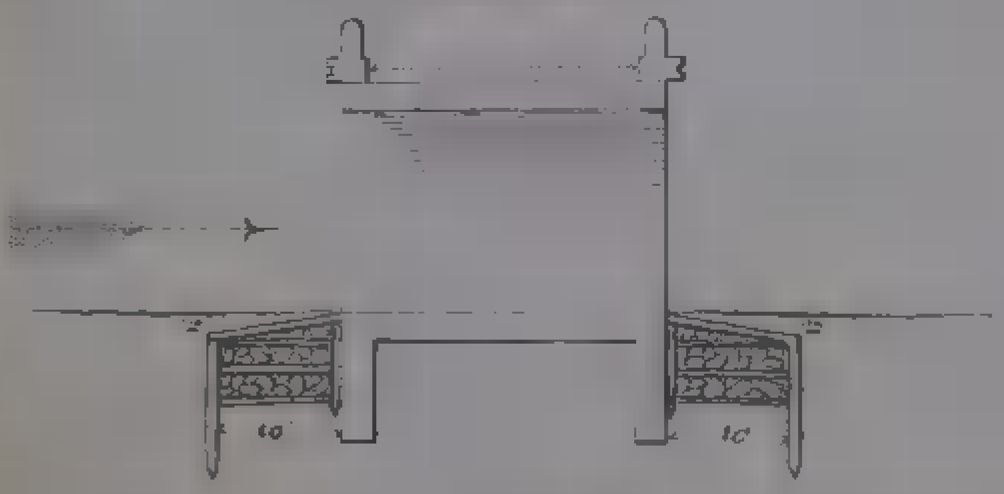


[illegible] bridges, [illegible] are [illegible] [illegible] to [illegible]
[illegible]
[illegible] the back [illegible]
[illegible] along [illegible] walls of approach
[illegible] and [illegible] of the bridges
[illegible] were the [illegible] in
foundations were laid
[illegible], of [illegible] instruction
laid down. In [illegible]
some cases where the ground was hard and of a [illegible] quality, the [illegible] and curtains were [illegible] to exceed 10 [illegible] less than [illegible] feet in depth, the maximum measurement being only necessary in the leading 100 miles of the course of the Grand Trunk line. –

3rdly Where the Canal [illegible] in the vicinity of a bridge was sand or [illegible] a light soil, the [illegible] were to be protected by a line of sheet piling with heavy ma[illegible] laid [illegible] agreeably to the standard plan adopted [illegible] the Canal works of these Provinces, the [illegible]

this protective covering being as follows

Diag. CXVI.



The flanks of the Canal on its meeting a bridge of this description, have also to be protected by piling.

4th As a general rule, borings of bed of rivers were to be prepared

5th The Roadways were to be properly designed, and to be constructed in width adapted to the particular purpose of the line of communication. e.g.

Imperial Roads the 36 feet width
District and other roads " 20 feet "
Village " " 16 feet "

these measurements were to be the clear width between the plinths of parapet walls, or between the brackets figured in Diagram CXVI

6th The drainage of all Bridge roadways to be effected through the crowns of the arch by [illegible] and cylindrical holes. –

7th As a general rule Bridges to be built at every 3 miles in length of the Canal, and its distributaries, deviations from this rule to be made the subject of special reference.

These were the leading points upon which the works of the Bridges have been executed; deviations have in many cases taken place, from causes which will [illegible]

be explained under the details of the individual works, generally speaking however, the above Rules may be considered as those which have been [illegible] in the prosecution of all works connected with cross communication. –

It will be understood from what has been said in former chapters that the floorings and curtains attached to the heads of gates are [illegible] elements in the [illegible] [illegible] the [illegible] of the [illegible], they were universally adopted in the Eastern Summit Level, and may be considered as the salvation of the bed of that work from the [illegible] of retrogression of levels, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] their value [illegible] was ~~are~~ is beyond all price. In the construction of bridges, however, they ~~[illegible]~~ have other ~~[illegible] [illegible]~~ uses which are worthy of consideration [illegible] their influence in checking the action of [illegible] in the bed of the Canal. They [illegible] a resisting medium to the thrust [illegible] as exerted through the abutment, [illegible] strength of which is in direct proportion [to] their own inertia & capacity to resist [com]pression. That such a medium is [an] important element of stability will [be] at once apparent when it is borne [in] mind that provided the abutment [is of] [illegible] masonry, & thus virtually [illegible], the value of the thrust against [the] floorings & curtains is in the direct [ratio] of the perpendicular depth from the [illegible] block to the fulcrum supplied [by] the floorings referred to.

In further illustration of what [illegible] and to the diagram appended hereunder I would here introduce two other diagrams representing longitudinal sections, [illegible] [illegible] through bridge ways as [illegible] [illegible] [illegible] passages.

Diag: CXVII

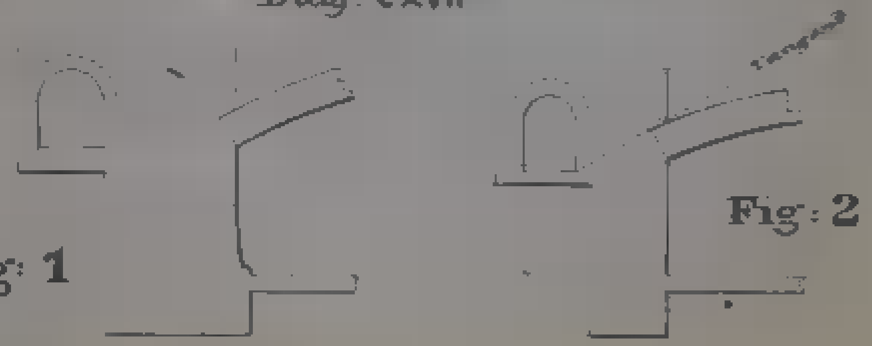


Fig: 1 Fig: 2

[illegible] order to give the fullest benefit to the rules of construction laid down in the above paragraph it is evident that before the arch is allowed to exert its action in thrust, the three elements of design must be complete, that is to say in the case shown in Diagram CXV, the bridge flooring must be built, the abutments must rest, only and directly upon the virgin soil, and the wings of approaches must be completed up to the height of the [illegible]. In the case represented in Diagram CXVII, Figure 2, that in addition to the requirements above stated the block through which the flowing path passage is effected must be complete in all its parts, finally that the whole of the masonry ought to be perfectly consolidated. With the material which has been used in these works, a rigid attention to the above rules must inevitably have led to the most satisfactory results.

The two leading elements viz. the conjunction of the virgin soil with the abutment, and the completion of the wings up to a certain height, were easy of accomplishment, although not unnecessarily [illegible] in works carried on at a distance from the Executive Officer, and under the management of native mistries or subordinates; the third however, or that appertaining to the floorings and curtains, was from causes which I will explain, necessarily carried out very imperfectly, and in fact to the fullest extent not carried out at all except in those cases where [illegible] centering were used.

In the construction of all arches with a span exceeding 15 feet in width, it was my original intention to have used timber centerings; circumstances, however, connected with both economy of time and expenditure of money rendered the scheme impracticable; in building the Bridges on the high[illegible] [illegible], the great expense that would have been incurred by multiplying the centerings required for so many Bridges was a consideration of no mean importance; and the delay in completing so many arches with a limited number of centerings would have been fatal to the desired progress of the work. On the other hand the adoption of earth centerings simple in the whole proceeding, it at once reduced the expense and constantly threw over the line of works an unflagging activity. This celerity of progress has enabled us not only to bring to completion works which certainly could not have otherwise been built in the time to which [illegible] completely restricted, but in the lower divisions where the scarcity of material has driven us to all sorts of expedients to reduce the cubic content of masonry, the adoption of the earthen centering has enabled us to vary the width of span, and to reduce it to a minimum adapted to the capacity of Channel over which the Bridge is constructed.

With the exception, therefore, of the few bridges which have been built in the [illegible] including Roorkee and of the six leading

Bridges

Bridges on the high land of the Coast every work of this sort as described in the present chapter, has had its arches built on centerings made either of earth alone or by a combination of earth and brickwork. As I have devoted the leading portion of this chapter to centerings, I need say nothing further here, than that by adopting the cheaper and more expeditious plan offered by earthen centerings, we were, moreover, permitted to build the facings [?] simultaneously with the piers and abutments, and have, consequently, in such cases, failed in completing the necessary elements required in Rule 1.

It will be observed in the section on cuttings that where the soil was of a good and tenacious quality, the piers and abutments were laid in up to the top plane or natural surface, the intermediate ground or that occupying the site of the arch being left in its virgin state to act as a support for the segmental superstructure required for building the arch upon. Until the arch was built therefore, and until the time for removal of the centering had arrived, the ground occupying the barrel had literally not been touched by a spade, it necessarily followed that the forming or excavations of which the substructure consisted were, instead of being the first, the last portion of the building executed.

Again in sandy tracts where it was necessary to remove all

of the soil, and in laying the foundations to great depths, to excavate with wide and extended slopes; where in fact the whole of the foundations were laid in a crater, which was after the completion of the walls filled in with loose sand, although the curtain walls were built, it was not thought advisable to complete the floorings, until the subsoil was sufficiently compressed. The flooring therefore, was delayed until the earthen centerings were removed and until the thrust of the arches had been brought to act upon the abutments; in this case, however, the 3rd element although not complete in all its parts, was present in the curtains or lines of foundation walls which give the true bond between the up and downstream masses of the substructure, it was incomplete only in the flooring itself. It will be understood, therefore, that timber centerings have been employed entirely within the two works on the Ganges Canal, or to the few bridges in its immediate neighbourhood, whilst by far the greater proportion of the Bridge arches have been built either with centerings of earth, or of any similar material of which earth is the predominating ingredient.

The second and third rules have been I believe in all cases implicitly followed. In the Roadie Bridges of which there are only two that come properly under the present description the [illegible] Bridge is laid on boulders to a depth

of

of 6 feet, and that at Jowalapur in a mixed soil to a depth of 8½ feet; in both these cases the [illegible] rule for protecting the head and tail has been rigidly attended to. On the high land from Roorkee downwards, as far as the 110th mile including the bridge at **Raoli**, the bridge foundations vary in depth agreeably to the nature of the soil. In the early part of the course of the Canal when it passes through the Muzuffurnuggur District, and where sand predominates the depths of foundations is never less than 10 feet; that of the works connected with the falls it will be recollected is in one case equal to 32'5 feet; in all these cases, however, the foundations are well protected. The soil below the Muzuffurnuggur District and in the upper part of that of Meerut is of a better quality, and in the latter district, however, we get into the region of spring water, and the depths of foundations depending very much upon this soil. From the **Raoli** Bridge [illegible] however, and throughout the Bolundshuhur and Allyghur Districts, the soil although in many places at a small depth below the canal bed of pure sand has not forced upon us the necessity of maintaining [illegible] depths of foundations; but in all doubtful cases, and where there appeared to be a probability of current action near the Bridge piers, those portions of the works have been most carefully protected.

To

On the Terminal lines, the soil almost universally is hard and tenacious, the depth of the foundations in no case exceeds six feet, and generally it is only four; the Position and [illegible] of the soil have [illegible] the difficulties [illegible] by [illegible] labour in procuring materials for building, as for many [illegible] to the works of the superstructure being built on a platform of masonry equal [illegible] to that of the [illegible], the foundation or certain walls in the [illegible] and [illegible] being at [illegible] equal to the standard depth. In these lines also [illegible] are given on the [illegible] in all cases where such appear to be necessary. As a further guard against accidents, and that not many anticipate, rather than [illegible]; every bridge, in fact every masonry work connected with the Canal channel, is supplied with a magazine or store of material, relative to the shape of boulders, blocks & [illegible], in the absence of [illegible] masonry. At each of the bridges on the Terminal Canal works, 10000 maunds or 350 tons, of this species of material are present on the spot, to secure an immediate remedy in case of accident.

The 4th Rule which prescribes a particular form of arch was generally [illegible] adopted even in cases where the situation is difficult for construction of a

a simple segment equal to the depth with [illegible]; in most cases the segment is [illegible] true, it enables us to give excess of height to the piers, and thereby to afford facilities for the passage of boats at high water. To the builder and Contractor, moreover, it simplifies calculations of Cubic Contents. The only deviation from the 60° arch is in a set of [illegible] which will shortly [illegible] which will be described in their [and on some of the smaller arched bridges in the Liverpool Terminal Line;] proper place. The increase of rise and the expense of [illegible] gained by the shorter radius [illegible] in my opinion no great penalty to [illegible] [illegible] them.

It has been [illegible] to me on [illegible] with that many of the bridges in anticipation of [illegible] will [illegible] they ARE [illegible] [illegible] [illegible] military roads had been designed accordingly. In the upper parts of the Canal where the width of [illegible], which is equal to nearly 20 ft, a roadway [illegible] to a width [illegible] is [illegible] unnecessary, whereas in the narrower parts of the Canal such a width of roadway would be sufficient for all practical purposes, laying down a [illegible] rule, therefore, [illegible] width of roadways on bridges [illegible] under different circumstances was somewhat inconvenient ~~[illegible]~~, although [illegible] [illegible], [illegible] was [illegible] an additional [illegible] [illegible] ~~[illegible]~~ would have added [illegible] to the Estimate. In the [illegible] of [illegible] [illegible] bridges which cross the Canal consist of [illegible]

only and the greatest width of the Canal Channel at its intersection does not exceed [illegible] feet, the Bridge roadways have been made to a width of 13 feet only, but it cannot be too often explained that the standing and unusual difficulties in procuring material of all sorts (especially brick) on the Cawnpore Terminal line from the 100th mile downwards, led to the adoption of the dimensions, as well as the [illegible] which may be considered extreme.

With regard to drainage the plan laid down in rule 6 has been in all cases adopted, by [illegible] holes of 12 inches in diameter through the [illegible] of the arches on both sides of the roadway; this gives a very efficient relief from the [illegible] to which we are subjected.

Very considerable modifications have been made in the 4th rule, which as compiled, was more intended as a general guidance, than to adhere to in its strictest sense. Practically speaking village roads have been, as far as such could be managed with propriety, limited to distances of 3 miles apart, but in all cases where the cross communication of the country would have been in the slightest degree interrupted by such an arrangement, it has been freely deviated from. This is more remarkably shown in the [illegible] and in the highly cultivated Districts lying below the [illegible]

regulators

Regulators; but even in the main Trunk line, where the extent of works for cross communication and the cost ~~which they recom-mend extension upon the Collectorates~~ naturally called for a judicious although restricted disposition of works of this sort, bridges have been built at all points where such were absolutely necessary, without reference to the special rule on which I am now remarking. In looking at the map it will be observed, that the longest tracts of the Canal [illegible] bridges, exist in the [illegible] and Mozuffurnuggur districts between Roorkee and the Meerut road from [illegible] in one case, and between the latter town and the falls at [illegible] in the other, the apparent deficiency of Bridges in these neighbourhoods arises from the direction of the [illegible]; the country across which it [illegible] is [illegible] cultivating, the [illegible] speaking [illegible] sandy, and in its present state adapted to the growth of [illegible] and [illegible] of [illegible]. This is re-markably [illegible] in the Mozuffurnuggur district but it is more or less common to the whole length. In building our Bridges however, their sites were determined at points most convenient to the towns and villages in the neighbourhood; in some cases it will be observed, at distances apart, very [illegible] considerably less than that laid down for our guidance. In the Mozuffurnuggur tract the disposition of the works is adapted

in my opinion to meet every future wants; that in the Sahaunfoor District where the extension is of a better description may be improved by additional bridges built at points equidistantly between the Rocker aqueduct and the Assoffnuggin falls, and between the Lebeilien — Bridge and the falls at Millwoodfoor. At both these points my Estimate of 1856 named the abutments of suspension or hollow bridges, an idea which has been extended by building [illegible] the substructure and continuing on the same design as that of the masonry bridges already constructing, viz. in 3 bays of 50 feet each with piers 15 feet in width, giving a space between the faces of abutments of 179 feet. Substantial [illegible] and [illegible] have been added so that we have the means ultimately of completing the [illegible] as [illegible] [illegible] structures, a plan that I strongly recommend [illegible] [illegible]. We [illegible] at [illegible] [illegible] by this arrangement added to the canal [illegible] two more retaining bars, in the maintenance of the slopes. — [illegible]

[illegible]

where every additional check to re-
-gression of levels, is of the most
serious importance; the inexpe-
-diency of extending the masonry
works however at Roorkee and its
vicinity beyond those of direct
necessity, arises from the Aqueduct
works absorbing every brick that
could be made, and it was with
the greatest difficulty that material
in sufficient abundance could
be procured for completing the
Aqueduct works. The con-
-struction of these works has been
constantly interrupted throughout
a period of no less than [illegible]
and it is only within the last
year that progress to the extent
of preparing the [illegible] channel
for the reception of the water under
the [illegible] and works of [illegible]
[illegible] and [illegible] in [illegible]
[illegible] has been carried on with
[illegible] of steadiness. To
build the piers and abutments
of an additional bridge in the
midst of such an overwhelming
demand for material was quite
out of the question, and although
the value to the bed in the exist-
ence of an additional retaining
bar would have led me willingly
to meet the wishes of the Civil
authorities, and although it
is evident that every additional
bridge gives increased means of
quick communication, I am by
no means satisfied that there
was [illegible] hardship as far
as the cultivators are concerned
in a village not having been built
at this particular spot, to the
Country

(P, V. ii)

~~County at large there can be no inconvenience, and with district roads made to bear upon the [illegible] [illegible] [illegible]~~

In fixing the sites of bridges for high military and district roads, every attention has been paid to the wishes of the local Committees in whose hands the funds for road making purposes are placed, and the Chairmen of the Committees have in all cases responded to the wishes of the Executive Officers, in connecting the cross and village roads with those bearing upon the bridges; in making roads to meet the bridge approaches when such did
2,225, 10 ft. w. ch. m. not exist before, and in giving to adjacent estates on the banks whose boundaries lie equidistant between 2 bridges, free and open communication with their approaches. A great deal of this most useful and necessary part of the undertaking has been completed, or is in progress at the present time, it is in full vigour in the Muzuffurnuggur, Meerut, Boolundshuhur, Etawah and Allyghur Districts, in which both the Civil authorities and the Road Committees have been as anxious to give the means, as the Canal Executive officers have been to carry out the works. It is most backward in the Saharunpoor District, although in the early years of the progress of the works a good deal has been done in the neighbourhood of Saharunpoor and Roorkee.

from Rooker to the southern limit of the District, which includes the [illegible] nuggur, Mungpore, [illegible] and Muhumoodpore [illegible] bridges, no work of the nature alluded to has been yet commenced; the Bridges there are isolated and are only useful to those whose estates [illegible] [illegible] on the track that leads to them.

The design of the Bridges has been regulated by two considerations somewhat antagonistic in their requirements; viz: the necessity of giving a sufficient height to the [illegible] above high water mark, to [illegible] of [redacted] free passage of craft and at the same time an equal necessity for placing the roadway at a moderate height above [redacted] level of [redacted] country that the ramps of approach may not be inconveniently elevated.

These two requirements having been given two parallel lines [illegible] [illegible] ated by a ~~[illegible]~~ minimum height [illegible] the elevation has been necessarily restricted.

In cases where the depth of [illegible] was great, the distance between [illegible] water mark and the top of the [illegible] ments was sufficient to obviate [the] difficulty arising from the [illegible] above mentioned, and in such [cases] elliptical arches have been almost universally used. Elsewhere [illegible] space has been gained by raising [some] of the Piers and adopting a flat [segmen]tal arch, by which as much [space] as possible is given to [redacted] passage [of] the whole width of the water [pas]sages for the convenience of access [to] different parts of the building [in] connection with Towing path [illegible] and Irrigation have been [illegible] as necessary part of the design.

* In elevation has been made as simple as possible, and limited to as few varieties as the nature of the works would admit of; with the exception of the Bridge at [illegible] [illegible] which from its position and height of road [illegible] from the [illegible] of the [illegible] [illegible] a [illegible] design, the whole of the bridges may be separated into 5 classes and placed under the following denominations viz.

1st Class. Elliptical Arches with [illegible] pilasters, [illegible] pattern. Plate XLIX, Atlas

2nd Class Segmental Arches with [illegible] pilasters, [illegible] pattern Plate L. Atlas.

3rd Class Segmental Arches with open [illegible] spandrels, [illegible] pattern plate LI Atlas

4th Class Segmental arches with Spandrels pierced by cylinders and with the towing path passages marked by rusticated pilasters, [illegible] pattern, plate LII Atlas

5th Class. Segmental arches, plain [illegible] pattern, plate LIII Atlas.

[illegible] [illegible] 2nd [illegible] [illegible]

rel[illegible] to the [illegible] of the different works not [illegible] applicable, any deviation that may occur from the specification were mentioned at commencing the work.

II. Bridges between the Head [illegible] Canal and Roorkee

The most important of the Bridges ~~[illegible]~~ which are built on the Ganges Canal are connected with the [illegible] and [illegible]s ~~[illegible]~~, [illegible] the works attached to [illegible] of [illegible] Aqueduct. There are only three [illegible] fall specifically under the head of [illegible] [illegible] [illegible] being unconnected with the great works above mentioned, and having no connection with [illegible] [illegible] supply [illegible] may be classed as [illegible] communication merely. The three Bridges which [illegible] under this [illegible] [illegible] are

1st The Kunkhul Bridge
2nd " Jowalapoor "
3rd " [illegible] "

The Kunkhul and Jowalapoor Bridges are of three Bays, [illegible] [illegible] opposite to the Towns from which they take their names and they are provided with roadways of 18 feet in width. These bridges have 3 Bays of [illegible] feet each, with intermediate piers of [illegible] feet. The roadways are in both cases [illegible] raised 24 feet above the [illegible] flooring, the latter being protected by [illegible] and boulder work, and the upstream and downstream [illegible] being [illegible] by [illegible] steps or [illegible] [illegible] the [illegible]

of Travellers.—

The Ghats attached to the Jowalapoor Bridge are designated the "Dalhousie Ghats" in honor of the Governor General by whose orders they were constructed on the application of the Inhabitants [illegible] town when his Excellency inspected the works in December 1851. To the left upstream flank of the Jowalapoor Bridge the [illegible] Channel head is attached. With the exception of the foundations and the massive parts of the [illegible] the whole of these works are built with brick masonry with an external coating of [illegible]

The [illegible] on the [illegible] Plates LXII of the Atlas were used in the construction of the works, and the [illegible] was as follows.

1 Part Stone Lime
1 " Soorkee
1 " Sand

The quantity of material used, and the rates of [illegible] are shown in the following Table.—

Bricks — 12"×6"×2½"	1055396		
do — 12"×6"×2"	265702		
Boulders	120819	maunds	
Stone Lime	56174	Cubic feet	
Soorkee	63687	do	
Masonry Abutments	15	3	6 per 100 cubic feet
[illegible]	7	6	11 per 100 cubic feet

The total cost of each of these works is shown by the following detail

Kunkhul Bridge	25853	6	3
Jowalapoor do	39242	9	11

They were built by [illegible] Assistant Engineer

Engineer of the works.

The [illegible] Kullam Bridge is for the passage of the high road between Saharunpore and Hurdwar; it is situated near a large [illegible] Mahommedan shrine, where there is an annual fair at which a large concourse of people is assembled. From the circumstance of the Canal Channel at its point of intersection by the bridge being of extraordinary depth, it was necessary to vary the design accordingly; its proximity to one of the halting places of assemblage on the route to Hurdwar also and the necessity of providing towing path passages on the [illegible] for the use of the railway between Roorkee and the [illegible] led to further deviations from the standard plan of bridge that was proposed for the [illegible].

The plan, sections [illegible] of the [illegible] Kullam bridge are given in Plate XXVI of the Atlas; the roadway is the same as that of the bridges at [illegible] [illegible]; [illegible] piers are 8 feet [illegible] the arches are segmental 160 [illegible] supported on [illegible] [illegible] by a [illegible] the edge of which [illegible] a [illegible] to the [illegible] of the [illegible] [illegible] towing paths [illegible] passages [illegible] 12 feet [illegible] breadth and 15.77 [illegible] high from the roadway to the soffit of a [illegible] segmental arch [illegible] These passages are [illegible] by [illegible] towers [illegible] to the [illegible] of the [illegible] which they are naturally corresponding. A plan

bridge is placed over the head of each of these passages. Above this, ~~the face of the bridge is [illegible]~~ is a simple bold cornice of double lines corresponding in character with the rusticated pedestals, the whole being crowned by a plain parapet wall. The height from the flooring of the locks to the bridge roadway is equal to 30¼ feet. ~~[illegible]~~ On the down stream flanks of the bridge, flights of steps lead to the [illegible] have been [illegible] for bathing purposes. On the upstream side the bridge flanks are protected by wings.

The high water which at the site of the above bridge existed on a level 12 feet above the bed of the canal, and which after the canal was opened, was maintained at moderate depths only by the use of machinery, led to a necessity for block sinking for the foundations of the piers and abutments. The blocks for this purpose were undersunk to a depth of 10 feet, and the substructure connected with them was arranged on the usual plan. The floorings of the locks were laid in to a depth of 2 feet with upper and down stream curtains equal to 10 feet in depth. Both the floors as above described, and the flanks of the bridge, as well as the fronts of the [illegible] are protected by aprons of [illegible] and brickwork. The [illegible] of this building is [illegible].

[illegible]

Although segmental, the arches correspond so far with the Elliptical curve of those before explained, that, with a slight alteration at the haunches, the timber centerings which were in use in the Solani works, continued their services at the Peeran Kulleear bridge.

Brick masonry was alone used in this building, with mortar of the following proportions:

1 Part stone Lime
2 – Soorkee

The quantity of material expended and the rates of the work were:

Bricks — 12" x 6" x 2½"	756800	
— Do — — Eng. Cob machine	285090	
Stone Lime —	17262	Cubic feet
Soorkee —	34892	— do —
Masonry — Plain —	19 5 9	per 100 cubic ft
— Do — — Arch —	32 14 5	per — do —

The cost including both bridge and Ghats amounted to Co's Rs 35307..14..0 it was built by Mr Parker the Assistant Engineer attached to the Aqueduct works.

Although the 3 Bridges above described are placed, by the order in the present chapter, it must be borne in mind that those which are included in the great works attached to the Solani are equally efficient for the purposes of cross communication. The length of canal included in the present chapter is 19 miles in length, in which independently of the superpassages of the Ranipoor and Puthri torrents which when floods are not running offer the best possible passage for the herds of cattle which graze in their neighborhood there are besides the 3 bridges also

Inclines

enumerated

1 Regulating Bridge at Myapoor
1 Bridge at 1st Falls
1 Do at 3 do
1 Cross Bridge at the Rutmoo works
1 Regulating Do Do
2 Bridges at the Solani aqueduct

so that there are no less than 10 bridges besides the super-passages making a total of 12 lines of cross communication over the canal channel in a length of 19 miles.

III Bridges between Roorkee and the Nanoon Fork.

On this line which constitutes the main trunk of the Canal in its progress from Roorkee where it enters the high land of the Doab, to the Nanoon regulators at which point the trunk is separated into two branches, the bridges without exception are on the uniform design of the four leading classes under which they may be placed numerically in the following order

1st Class	7	Bridges with	3	spans of	55 feet	each
2nd do	14	do	3	do	45 feet	do
	3	do	3	do	40 feet	do
3rd do	5	do	3	do	35 feet	do
4th do	10	do	3	do	30 feet	do
——	1	do	super-passage at [illegible]			

The designs for the 1st class are described in the former statement under the head of the Roorkee and Gowalipoor roads, [illegible] which were as a pattern, [illegible] for the works now under description. They have towing paths, in which respect they differ from those heretofore described, attached to the left flank or the left way, consisting of a timber platform

suspended

buttresses or uprights which cause no impediment to the free passage of the water through the way. The water way and the span of the bridges crossing the canal are similar to those in the header, with the exception of the bridge at Munglore where the latter is 1575 feet. At the village of [illegible] [illegible] between the [illegible] and at Gunespoor mile [illegible] the canal [illegible] [illegible] which [illegible] have been built as I have before explained for ultimate purposes, to be completed as [illegible] bridges.

Gunespoor

The [illegible] of the canal as far as 110th mile is of a [illegible] and [illegible] description which [illegible] to the [illegible] of [illegible] measures [illegible] the preservation of the [illegible] [illegible] other [illegible]. At [illegible] of Mungalore [illegible] [illegible] Dewat, [illegible] [illegible] Ghats have been constructed which whilst providing the means of access to the water, give good protection to the [illegible] on the approach to the bridges. The [illegible] Bridge which lies at the 62nd mile and is similar in design [illegible] has a roadway of 24 feet in width, to adapt it to the purposes of the high Military Road between Meerut and [illegible] to which it affords a passage over the canal. Ghats here [illegible] approach to the water are [illegible] designed on a more elaborate scale than elsewhere; they are situated on the down stream side of the bridge to which they are

attached.

attached, whilst the upstream side is protected in the usual way by plank curved revetments. For a detail of the different bridges with the works attached to them, reference can be made to Part II in the 2nd Section of the 2nd Chapter of which a full description is given; and there appears to be no necessity to encumber the text with a detail of material and rates of each work, when the whole can be found by turning to the Table 5 in the appendix. It will be sufficient in this place to note that the Bridges under not [illegible] which are included in this Section are built of brick masonry with cement made of lime and [illegible] (pounded brick) that they are all stuccoed externally, and that the roadways are metalled with [illegible]. Their approaches from the country are by ramps or inclined roadways laid out on a slope of 1 in 50.

The average rates per 100 cubic feet of Brick masonry on the above works may be estimated at Rs 65 [illegible] 7. 1; and the average cost of a Bridge without Spits at Rs [illegible] 231 [illegible] 10. 8 –

The depths at which the foundations of the different bridges were laid will be seen by referring to Plate XLIX in the Atlas. –

Amongst the Bridges which come under the 2nd class are those extending from ~~Rewa~~ Peeruhpera at the 106½ to that at Chapra at the 171½ Mile; the whole of the bridges from the 106½ Mile to the termination of the Main Trunk being built on the same general

design

design.

With the exception of the bridges at Ravli, Kepulkera, Dhunkowa and Uchaliya, they are connected with the heads of Rajbuhas and Inlets as shewn in plate [illegible] of the Atlas. In the exceptional cases, wings and short lines of groynes are attached either [illegible] up or down stream faces of the [illegible] and in some cases to both.

There are 2 descriptions of waterways, viz. One having 3 bays of 20 feet each, [illegible] the line from Kepulkera to [illegible] [illegible] the other having 3 bays of 20 feet each in width. Of the former there are [illegible] bridges, of the latter there are 8.

These Bridges have in addition to their waterways [illegible] arched passages 5 feet in width [illegible] through the wings, to [illegible] towing paths, which are uninterrupted passages maintained along the canal. Connected with the heads of Rajbuhas which are on the upstream sides, are lines of groynes with a platform and retaining wall for the purpose of giving access to the water, & giving free space to the apparatus required for regulating the Rajbuha head supply; and also for protecting the Rajbuha head from inconvenience which would inevitably arise, were it in close proximity to the Bridgework. At the Bridges at Moonga Nugger and Wullefoora, over which the great roads of the country cross the line of canal, the groynes are extended to a length of 200 feet, leaning upon the bridge flanks in an Ogee Curve and

and approaches from the higher levels of the Roadway embankments by flights of steps. The berm platform is reached by steps appended to the wing walls of the bridges, [illegible], similar steps being provided at the Inlet and Regulator Escape. On the down stream side the bridge is usually terminated by plain curved revetments sweeping into the earthwork. In some particular cases, however, at the Dumkowra and Nerunja bridges for instance, flights of steps or Ghats giving access to the water from the berm levels, have been added, affording additional facilities for approach to the Canal stream. In all cases where it has appeared to be necessary, protective aprons to the walls coming in contact with the current have been adopted. In the Rohilcund and other districts where Block Kunkur is abundant, this species of material has been substituted for the fine-grained brickwork which is used in the Northern Districts.

The facilities with which Block Kunkur has been procured at all points through which the series of bridges extends, have led to its adoption to a very great extent for building purposes; with the exception of brickwork nearly the whole of the bridges now under description are built entirely of Kunkur, and in the case of the Kasimpoor Bridge the external faces of the arches themselves are made of this material.

The design of [illegible] differs in no respect from that which I have [illegible] excepting in having a [illegible]

[illegible]

instead of an Elliptical arch, and in having a raised pattern to the perpendicular faces of the Piers, Abutments, retaining walls, &c. From the reduced depth of the Canal section, and the height from the roadway to the key forming being only 19½ instead of 24 feet, the proportions of these bridges are better than those of the works in the upper District. There is greater harmony between the parts, and their general outline is more agreeable to the eye, than the more elevated structures formed as it were between enormous embankments. Where brick has been used, as in the archwork, and occasionally in other parts of the building, the material has been burnt at our own manufactories in the [illegible] brick, the size adopted being 12" x 6" x 3" and the quality excellent.

A detail of all these works, with their appendices, details, &c, will be found in the 2nd part and that of the material expended, rates for each separate trade, forms part of a Table in appendix J which is especially drawn up for the purpose of giving the fullest information on the subject. -

The description of [illegible] requires no further illustration than that the exterior of the bridges is stuccoed, and that the Cement used consists of

1 Part of Kunkur Lime, to
1/20th of White Stone Lime -

The roads of approach both from the Country and from the Canal embankments, are laid down on an uniform slope of 1 foot in 50 [illegible]

[illegible] on the Grand Trunk Road where this has been diminished to 1 in 100. The roads are metalled with Kunkur, and where the Ramps of approach are much elevated, the sides are turfed, and the roads planted with [illegible].–

The average rates per 100 Cubic feet on which the bridges of this class have been constructed may be estimated as follows:

Arch Masonry	per 100 Cubic feet	14	4	.
Other do.	do.	11	.	8
Plastering	per 100 Square feet	2	3	4

And the average cost of the Bridges at

Rs 10090 . 10 . 1 each for 135 feet whole length
10504 . 14 . 1 do 120 feet do

The depths at which the foundations of the different bridges are laid are indicated in Plate L Sect 3 of the Atlas.

Of Class No 3 there are five Bridges only, and these are wholly confined to the line of road lying between the [illegible] Head and the Town of [illegible], or more properly between the 83rd and the 91st mile, at which points the Bridges of [illegible] and [illegible] both of which belong to the above class constitute the 2 extremes of the series. The design was adopted [illegible] the material, which consisted of small bricks ranging in size from 4×3×1½" to 9×3½×1½" procured from numerous old ruins [illegible] in the neighbourhood, the most [illegible] source being an extensive [illegible] at the Town of [illegible]. These ruins consisted of the small brick [illegible] admitted to [illegible]

[illegible]

with mud, an ingredient difficult to get rid of when applied in the brick to the new work, and which undoubtedly might have been dispensed with with great advantage. The bricks, however, were washed and cleaned before they were placed in the works, and whatever might have been their defects they were of the greatest aid in accelerating progress. To meet the material in question it was considered necessary to extend the segment of the arches beyond the standard limit of 60° as it was supposed that with an increased versed sine or rise there was less risk of failure from the contingency of bad brick burning. The versed sine thereof was increased from 1/5th of the span as that formerly fixed [illegible] 60 ft, 2/3rd [illegible] to a height of 10 feet. The apparent disproportion caused by the rise of segment, was broken by a series of arches perforated through the bridge and occupying the whole space bounded by the extrados of the arches and the line of cornice. The parapets were in open rail work, the diameter of the pillars corresponding with that of the small brick with which we had to deal. Narrow footpath passages six feet in width were designed on each flank of the main arches their approaches being covered by curved revetments, or as in the case of the Sansut bridge by lines of [illegible]. The bridge wings are fitted with steps on their concave or outward side for the convenience of descent from the roadway to the towing path levels. The bay flooring

the

the flanks were protected by piling and apron work where such has been considered necessary, and nothing has been neglected to render the substructure secure from the effects of the current. –

The Roadways of the 3rd Class Bridges are elevated 2½ feet above the bay floorings, they are metalled with Kunkur, and drained by vertical holes through the crowns of the arches. The ramps of approach from the [illegible] are made on the usual slope of 1 in 50. –

A detail of all these works will be found in the table in Appendix J before referred to, which will give all the necessary [illegible] of expenditure and rates [illegible] consisted of

5 Parts of Earth and
1 " Gravel

and the bridges are externally plastered

On an average the rates per 100 Cubic feet are equal to Company's Rupees 12. 15. 3

and the average cost per Bridge without [illegible] may be estimated at Co's Rs 12636. 3. 6

The depths of the foundation are shewn in Plate L1 of the Atlas

Of Mark H, there are ten bridges, extending from the 77th to the 103rd mile, or from the [illegible] Bridge or that below [illegible] to the Bridge of [illegible] a village situated where the high Military Road connecting Meerut and Delhi

The waterway of these bridges is divided into 3 Bays of 50 feet each in width, separated by piers of $6\frac{1}{2}$ feet. The arches are 60° segments. The spandrels are perforated by cylinders which pass through the work, the up and down stream points being finished by a coped or benched facing. The wing walls which terminate at the spring of the arch are plain segments meeting in a point towards the stream. The faces of the bridge are quite plain. On each flank and in prolongation of the towing path is a passage six feet in width maintaining a free line of communication along the berm. These passages are flanked by rusticated pilasters. The wing walls of the bridge, all those which open out towards the country are fitted with flights of steps to give access to the berm from the top of the embankments. The whole is crowned by a cornice and parapet in the usual standard dimensions. Plans and sections of both class bridges will be found in Plate LII of the Atlas.

As a detailed description of these works, showing the precise nature of their appendages in the way of flats and planking defences is given in the 3rd part, and as the Table in Appendix gives full information on material, I need only remark in this place, that the same attention that has been given elsewhere in the protection of floorings and sides wherever the bed of the Canal was of a

natural

nature requiring such protection has been given with an unsparing hand to these works. At the Grand [illegible] Bridge which is situated on the road between [illegible] and [illegible], a series of spurs similar to those which have been built at Khudowli [illegible] are now attached to the [illegible] stream side of the works; to the upper side protection has been afforded as at [illegible] by [illegible] revetments.

The foundations and the nature of the soil over which they were laid will be understood by reference to plan No. LII. Spring water was frequently met with in this line below a moderate depth.

The roadways or approaches of [illegible] bridges are gradually [illegible] the design of the roadway to the works of the Bridge road in a slope equal to 1 in 30. The bridge road also [illegible] metalled with [illegible] [illegible] [illegible] and [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] bridges with the [illegible] road [illegible] [illegible] of the [illegible] is 1975 feet.

The works included in this [illegible] are [illegible] built of brick masonry, the [illegible] of which was [illegible] either Kunkur lime alone ~~[illegible]~~ or ~~[illegible]~~ Earth lime mixed with Soorkhee, on the following proportions.

2 parts of Earth lime
1. do 1 Soorkhee (pounded brick)

[illegible] [illegible] [illegible] [illegible] agreed [illegible] [illegible] [illegible] practice on these works.

The average rate per 100 cubic feet of brick masonry may be considered as Rs 12. 9. 6.

[illegible] out [illegible]
and the [illegible] [illegible] of [illegible]
as [illegible] [illegible]

The only [illegible] that remains to be described on the [illegible] extending from [illegible] to [illegible] [illegible] is the [illegible] bridge [illegible] that at [illegible] described [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. This bridge is on the high road between the [illegible] and [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] above it being raised above the [illegible] [illegible] [illegible] [illegible] six [illegible] in breadth [illegible] [illegible] [illegible] [illegible] [illegible] the body of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Passages [illegible] that at [illegible].

[illegible] the [illegible] [illegible] roadway [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with those above described. Its foundations are [illegible]

[illegible] [illegible] [illegible] is built [illegible] brick and [illegible] [illegible] [illegible] [illegible] following ingredients

2 parts of Earth Lime
1 Do of Soorkhi

and it [illegible] [illegible] [illegible]

The [illegible] [illegible] [illegible] [illegible]

[illegible] to the Spring water surface [illegible] lies at a Depth of six feet [illegible] the bed of the Canal; they are [illegible] [illegible] [illegible] the up [illegible] [illegible] by a Double line of piles, the [illegible] spaces being filled with large [illegible] block Kunkur. The flooring [illegible] the Bridge is protected [illegible] [illegible] [illegible] [illegible] face by aprons [illegible] in width extending from one side [illegible] to the [illegible]

of Training is on an average of the whole work Rs 13. 5. 5

and the total cost of the Bridge was Company's Rupees

31571 „ 12 „ 0

In the district which I have just described and which embraces a series of works on a line of 161 miles, there have independently of the bridges above enumerated, which are [illegible] to be, (241, R. Vol. 2. Part III. Ch. iii) [illegible]

11 Tanks, the ways over which are mostly Bridges

24 Regulating Bridges at the heads of 13 [illegible]

giving a total of 59 points at which the Canal may be crossed by the public. In addition to this, frequently [illegible] occasions have [illegible] in the [illegible] previously [illegible] the admission of [illegible] for the building of ~~[illegible]~~ footworks [illegible] the villages [illegible] ~~[illegible]~~ any [illegible] built. 59 Bridges [illegible] on the above distance of 161 miles [illegible] an average of [illegible] miles between each bridge [illegible] those ~~each~~ [illegible] ~~[illegible]~~ [illegible] [illegible] 243 [illegible] roads [illegible] laid out, and brought to [illegible] from the Bridge approaches [illegible] from the villages [illegible] [illegible] intermediate between the bridges, [illegible] [illegible] with the [illegible] authorities in making equitable adjustments in the [illegible] so [illegible], the number of 13 [illegible] now built [illegible] be sufficient for a [illegible].

IV. Bridges on the Jumna Line between the Jumna Fork and the Ganges and Jumna.

This section includes the whole of the bridges which lie between the Cawnpore Regulators and the heads of the Etawah [illegible] works i.e. in the case of the Cawnpore Terminal line to the Cawnpore Bridge, in that of the Etawah line to the escape at Moosanuggur. With very slight modifications in those, & in a few instances to which I shall draw especial notice, the whole of these works belong to the 2nd class; the whole of them moreover would have been on the regular graduated system of water-ways (the roadways standing 33 feet in breadth, and less than 20) had circumstances arising from difficulties in procuring Material on the Cawnpore Terminal line not interfered &c. My desire was that throughout the whole of these works the design should be in strict conformity with that plan, as well as a general exception be universal. The few cases in which these arrangements have not been built are consequent on the inapplicability of the site for the purpose. It will be understood, moreover, that the rules for bridge building which have been explained in the early part of this Chapter were kept in view in full force. With these few remarks I commence with

A. Cawnpore Terminal

line

From Ramoon to the Dubodi Deufer which lies at the head of the Ramfoor Terminal works, and to which point the bridges I have here described are limited, the distance is 165 miles; the rectangular section of the canal channel varies from a maximum of 80 to a minimum of 40 feet in width. The design for water ways upon which the bridges were commenced was as follows.

From 1st to 30th mile	3 Bays of	33 feet each			
" 30th . 50th	"	3	"	30	"
" 50th . 70	"	3	"	26	"
" 70th . 85	"	2	"	33	"
" 85th . 120th	"	2	"	30	"
" 120th . 140th	"	2	"	25	"
" 140th . 150th	"	1	"	30	"
" 150th . 165th	"	1	"	25	"

From so an equal series of dimensions much of the labor in details might after having done one bridge be at disposal in completing the others. I have elsewhere described the cause ~~of the necessity~~ which led to an alteration in the above arrangement, and which forced us, even at the expense of additional labor to the department, to submit to a more minute graduation of the water ways, thereby reducing the cubic content of each work, and the quantity of material. The dimensions of the water ways in the revised plan have been shown in the 2nd Part, when describing the [illegible] development of the canal.

Although the [illegible] in width [illegible] the bridges were [illegible] design with the exception of ~~[illegible]~~ ~~[illegible]~~ 3 of the [illegible] bridges in [illegible]

the upstream side of Dubouk, a description of which will be given presently. They consist of plain 60° segmental Arches, supported on piers both with and without batter, the cutwaters terminating at the springing of the arches; these cutwaters are finished by a cornice which encircles the pier, and from above which the springing of the Arch commences; the tops of the cutwaters on the up and down stream sides are covered by an [illegible] sloped dome. [illegible] [illegible] are leaving [illegible] passages 4 feet in width. The wings of approach are in their [illegible] on [illegible] side fitted with steps for the convenience of access to the [illegible] levels. In all other respects the face of the bridge is made plain, relieved by a cornice and parapet of as few parts as possible, and in every case the roadway, and consequently the string and cornice is perfectly horizontal.

In cases where Aqueducts and Inlets are attached to the bridge, the design is precisely the same as that explained in the 1st Section. The Ramps of approach are on a slope of 1 in 36, excepting at the crossing of the Grand Trunk Road and its branches, at which points this has been reduced to 1 in 100. In ~~all~~ minor details our general design has been produced in all these works; differences in the parapets and cornices being the only deviations from a strict uniformity.

The soil throughout the Cawnpore Terminal line is [illegible] for foundations, in very few places have we come in contact with

kun–

sand. And generally speaking the virgin earth is as hard and compact as it could well be. Beds of Kunkur in block or in tabular masses have (strange to say from its abundance in the neighborhood) seldom been met with, but in the form of loose gravel it is universally found either in beds or scattered indiscriminately through the soil. — Superficial efflorescences of Soda are characteristics of all this part of the country; the Alkali is as I have before said very injurious to brick making, and I may as well be mentioning to Brick or Kunkur structures which are raised in connection with it. — The nature of the earth on which the foundations have been laid, has led to great variety in their depths; the curtain walls or those stretched across the channel and forming the up and down stream sides of the Bridge foundations have in all cases been carried to the standard depth, the cross walls or those on which the piers and abutments rest have frequently when the soil was good been omitted, the superstructure being raised on a massive flooring, extending over the whole surface from the back of one abutment to that of the other, and in frequent cases between the 100th and 165th miles the counterforts in rear of the abutment walls or the ~~arches~~ supports upon which the flooring & path passages rest elsewhere, have been ~~also~~ omitted. For plans and sections of these foundations see Plate
LIII of the Atlas. —

The material used has depended entirely upon the re-
=sources

-sources of the officer engaged in any particular part of the line in some cases Kunkur has been the sole material, in others brick whereas it has been by no means uncommon to use both brick and Kunkur in combination. At the villages of Husseypur, Bahosi, Gohaha, Oomunda and Sugguljpoor, the Arches of the Bridges are built of Kunkur, which at this point is of a very superior quality, free from the honeycombed texture which is the characteristic of the Kunkur formation, and quite as compact as many of the newer limestones. As a general rule how-ever, the arches the largest of which has a span of 35 feet [illegible] are built of brick. The cement consists principally of

3/5th Kunkur Lime
2/5th Soorkee or Bujree

the detail of which, together with the amount of material, it will be found in the Table as appended.

The various rates have been as follows:

Arch masonry per 100 c. ft.	21	8	6
Plain do do	14	7	9
Plastering per 100 s. feet	3	1	9

and the average cost of a Bridge may be estimated at

[illegible]	each	33 feet	span	11045	13	2
do	"	32 feet	do	10935	1	5
"	"	31 "	do	11081	8	
"	"	30	do	10050	5	7
"	"	[illegible]	do	9932	13	4
"	"	28	do	9891	12	11
"	"	26	do	9859	15	
"	10	35	do	9514	7	5
"	"	33	do	9637	13	5
		32	do	9583	3	1
	"	30	do	8747	12	4
		25	do	7721	.	.

The Bridge on the high road between Mynpoorie and Agra designated the "Dunahar Bridge" consists of Segmental Arches of span each; and differs from those of No 5 Class by having rusticated pilasters which stand upon the cutwaters of the piers, and flank the tow-

-ing practicable passages. With the exception of these trifling deviations from the standard plan the bridge comes [illegible] in all material points with the others. It is built with kunkur and brick [illegible] and, on the proportions laid down for Bridges over High Military Roads.

The old road between Mynpoorie & Agra [illegible] crossed the Canal at an angle of 65 degrees, the alignment was very irregular, and although metalled and raised sufficiently above the country, was open to much improvement. I had in all cases avoided skew bridges, in consequence of the great additional expense that they would lead to, as well as that the only legitimate excuse for departing from the rectangle is where the crossing occurs in the midst of towns or lands of a very valuable description which would be injured by an alteration of approaches, or in cases where the facilities of thoroughfare would be materially benefitted; as neither of these desiderata existed at the crossing above alluded to, the Gunahar bridge has been constructed at right angles to the axis of the Canal, and the approaches have been brought to bear upon it in curves, as shewn in the plan of this particular work. The whole of the approaches have been laid out with great care under the eye of the Executive Engineer, and I do not anticipate any objections to the omission of the skew.

The average rates for the work at the Gunahar

[illegible]

Bridge a/c

plain masonry	15 [illegible] pr 100 cub ft
Arch do	21 [illegible]
Plaster	2.10 .. pr 100 sq ft

and the total cost of the work is Co's Rs 12419-1-4.-

On nearing the 145 miles the bridges are reduced to waterway of ~~31~~ 25 feet in one segmental arch. Of this description of Bridges there are 8 [at Koorsoulli, Bana, and Muswanpoor having 2 ...] With the exception of the Pilasters between the ~~[illegible]~~ passages ~~[illegible]~~ and the main arch, they are in design and construction similar to those here described. At the village of Khujooa where the canal is crossed by the high road between Cawnpoor and Kalpi, the bridge which is over the last mentioned above noted, is built on a skew with an angle of 37 degrees the road in its approach to the canal crossing being out of straight inclination, and the uniform dimensions of the angle of intersection was at the same time moderate; here, therefore, was a case where the skew pattern might be ~~very~~ appropriately introduced, and it has been completed very satisfactorily, leaving the original alignment in its former state. The bridge both up and down stream is protected by parapets with steps of descent, and the wing levels of the roadway. The ramps of approach are on a slope of 1 in 100 and the finishings both in masonry and earthwork are of the same description as elsewhere.

These Bridges are built entirely of brick with Cement consisting of

2 parts of Kunkur Lime
1 " of Soorkee or Bujree

The average rate per 100 cubic ft of Masonry may be estimated at

For Arch work	Co.Rs 19..12..3	per 100 cubic ft.
" plain "	13.12 6	" "
" Plastering	3..4.6	per 100 sq ft.

The cost of each of the plain single arched bridges was on an average equal to Rs 6544. 12. 4 — that of the skewed bridge at Khujooee was Co.Rs 9341. 10. 0

On the Cawnpore Terminal line from the head at Nanoon to the Dubowli Escape, which as I have before said is 165 miles in length, there are 57 points at which the Canal can be crossed by the public, the average distance between each bridge being 2.89 miles. This with a proper arrangement of roads (the position of the bridges having been determined with reference to straight lines drawn between the leading towns in the districts and especially by the radiation of village tracks towards the main roads of approach) ought to throw the whole country open and render the means of cross communication sufficient for all practical purposes.—

B. Etawah Line

From the Nanoon Regulators to the Moosanuggur Escape at [illegible], between which the bridges in this section are limited, the distance is 170 miles. The channel is very similar in capacity and the design for the bridges varies in no great degree from that which was laid down on the Cawnpore Line. — There, however,

however, the resources of the Country have enabled us to maintain our Bridges on the original scale, and to construct them with the fullest liberality of material.— At the period that I am writing I may however observe that the works have not been advanced further than the 110th mile, and therefore, that the Districts parallel to those in which the Executive Engineer of the Cawnpore Line had so much difficulty in procuring labourers & materials have not yet been reached. Lieut. Whiting, the Executive Engineer of the works does not, however, anticipate the difficulties on account of resources met with by the Cawnpore Terminal Line and there is little probability therefore, of our being prevented from completing the bridges as they were originally designed. These Bridges are as follows:—

From 1st to	10th mile	2 bays	of	33 feet	each
" 10th "	30th	do	3	do	30	do
" 30th "	50th	do	3	do	26	do
" 50th "	70th	do	2	do	33	do
" 70th "	90th	do	2	do	30	do
" 90th "	110th	do	2	do	26	do
" 110th "	130th	do	1	do	33	do
" 130th "	150th	do	1	do	30	do
" 150th "	170th	do	1	do	26	do

The design of the whole correspond-ing with that under the 5th class with the exception of the single arched pilastered bridges which are on the upper [illegible] side of the Moosanuggur Escape.—

The detail of all these bridges noting the extent of spans and appendages to each, has been before given in the 1st part of the

paper, and the rates and detail of material used, will be found in the Table in appendix, ~~It~~ may be ~~sufficient to state that~~ the average rate for 100 Cubic feet of Brick masonry, be estimated at Rs12.5.9 and that of Kunkur at Rs 11.12.0 and the average cost of Bridges as follows:-

3 Arches of 33 feet each	10892	9	8
3 " of 30 "	10121	4	4
3 " of 26 "	9143	6	9

The nature of the soil on the country through which the Etawah line runs, is very similar to that which we have described in the former section, it has all the advantages of tenacity and retentiveness, and all its evils of local admixture with soda. As a rule however, it is well adapted for foundations, and for the sustaining of abutments or retaining walls, when such walls are placed in contact with the virgin soil. The material both in brick and lime, and the method of using both either combined or separately, are common to both the Etawah and Cawnpore Lines; and as the standard rules for construction are the same in both, there appears to be no necessity for repeating what has been already said in a former section.-

We have within the limits of our present detail a number of bridges equal to 40 scattered over a line of 110 miles in length giving between each Bridge an average

an average distance of 2.75 miles. The same remark which I made on the subject of roads applies here as it did elsewhere, the only way that the bridges can be turned to proper account is by opening lines of approach to them, the funds for doing this are in the hands of the civil authorities and other local road committees, each or both of whom will render the most ready aid from the local authorities, if they please to take advantage of it. At the time that I am now writing considerable progress has been made in laying out and constructing roads connecting the bridges on the Cuttack & Ganjam Provincial line, most of which have been completed between the [illegible] Head & the High level bridge [illegible] and [illegible]. I am greatly indebted to the exertions of [illegible] [illegible] of the Engineers, the Executive Engineer of the Cuttack Provincial line for the great progress that has been made in road making in the Districts connected with these works.

V. Bridges and Branches

This section includes the Bridges on the Futtigunj, Bolund-shuhur and other Branches, which from various causes before explained have, up to the period at which I am now writing, been only partially provided with. With the exception in part of initiatory surveys, the completion of the leading 6 miles of the Bolundshuhur Branch, & the arrivals of material in the early part of the Futtigunj and Bolundshuhur Branches, and the completion of the works at the heads, nothing has been done. In the design of the Bridges however I had no idea of deviating from that which has been followed in practice on the main Trunk line; the plan of combining with the bridges the different works, or inlets and the like, appears to have great advantages, in both compactness of design and convenience of supervision; it gives good drainage to the bridges in the neighbourhood of the approaches which must necessarily be much elevated, and the flat segmental arches, by admitting of increased rise to the height of the piers, gives facilities to the transit of boats and rafts, whilst they secure to the roadway the smallest possible rise above the level of the country. ~~[illegible]~~

The width and capacity ... of the Rajbuha heads might be retained at the minimum width ..., used on the Main Trunk line, with a width of 6 feet; that of the inlets I would

retain

clause in the standard measurement, which gives space for the introduction of "Chawkis" for the purpose of clearance. The length of "Ghats" or face, requiring protection to the head of the [illegible], and the "retaining wall" in the rear, might be very much reduced, the former to a mere platform sufficient for working purposes, or altogether, steps of descent being constructed, as has usually been done hitherto, on the concave surface of the wing walls. Unless experience points out that the position of the Rajbaha heads with channel thus designed is inconvenient, and liable to interruption from silt and sand deposits, the modified design for the Branch Bridges as above suggested will, I think, be acceptable, and at the same time moderate in cost.

Under the above explanation and in the order of precedence in which the branches are situated on the main works, I would for the [illegible] Branch adopt the following dimensions for waterways:

	Width of Waterway at the Channel	Bridge Waterway	Bays Number
From 1st to the 15th mile	70 feet	75	3 Bays of 25 feet
30th do	65/60 feet	60	3 do of 20 do
69th do	55/50 feet	50	2 do of 25
108th do	45/40 feet	40	2 do of 20 do
132 do	35/30 feet	30	2 do of 15 do
150 do	25/20 feet	25	1 do of 25
180th do	—	20	1 do of 20 do

For the [illegible] and [illegible] lines where the width at the head is 50 feet, the table above given would be equally applicable.

For

For the elevations, Class 5 would be that appropriate to all the bridges with more than one arch. The single arched bridges might be similar to those — in the vicinity of the Terminal works on the Cawnpore line — that is to say with the towingpath passage flanked by pilasters; or, what would be more economical and perhaps more appropriate to village and country bridges they might be made perfectly plain like those in Class No. 3 above noted.

It is unnecessary to say anything further on the construction of the above works, as they are repeats of those which have been already built, of which plans and all necessary details are shown in the Atlas.

This chapter would be incomplete were I not to add some concluding remarks on the Bridges which have been described in the preceding pages and which have been completed previously to my resigning the Directorship of the works. These remarks will naturally apply to the classes separately, an arrangement that will enable me to more readily review the different items under their respective classification. Commencing therefore with

No. 1. Class

The standard design of which is figured in Plate XLIX of the Atlas

The Bridges under this class are as follows, including those which are attached to the

[illegible]

[illegible] Aqueduct [illegible]

1. Nunkhel[?]
2. [illegible]
3. Upstream [illegible] Aqueduct [illegible] (headworks)
4. Down Stream [illegible] Do. (Eastern)
5. [illegible] (sub. [illegible] only)
6. [illegible]
7. [illegible]
8. [illegible] (substructure only)
9. [illegible]
10. [illegible]
11. [illegible]
12. B[illegible]
13. Khat[illegible]

The [illegible] works are as I have above explained left in an incomplete state, so that they may hereafter be finished ~~[illegible]~~ with masonry arches ~~[illegible]~~.

The five [illegible] Bridges on the list were built under the [illegible] [illegible] of [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] by them [illegible] ~~[illegible]~~. The arch of [illegible] with an elliptical [illegible] of its intrados is as will be seen by the plan & segment, the voussoir being brought to bear on the centre [illegible] impost blocks or [illegible] on which it rests are formed by horizontal brick work which is projected so as to form the lower portion of the elliptical curve. In one instance only, viz: at the [illegible] Bridge this rule was experimentally departed from, the voussoir in that case being brought to bear upon

[illegible] and the arch were constructed on an ellipse.

The thickness of arch was 3 ft, [illegible]

~~[illegible]~~

with the exception of the arches [of] the Khatowli bridge which were on centerings made with planks. The arches of the above Bridges [were] built on Timber ribs resting on cross walls of brick with mud cement

On my resuming the works early in 1846, the piers and abutments of the Ruttmul, Jowalapoor, Mungalore and [illegible] bridges were completed; timber centerings had been prepared or collected and the works in question were in progress of [illegible]. The brick manufactories which had been since the year 1842 in progress, under interruptions of various kinds, had at this period arrived at a fair state of organization and from the Head works to the Town of [illegible] not only had large supplies been provided, but kilns were in progress in sufficient numbers to secure an energetic advancement to the masonry works. The whole of the bridges therefore, which are included in the present class were completed without delay.

With the exception of the 2 Bridges which are attached to the aqueduct and to the works in the immediate vicinity of Roorkee, none of these bridges have escaped without settlement after the superstructure was built, this was shown by slight opening on the parapets over the crowns of arches, generally speaking not extending below the crown and in all cases [illegible] those of the Mungalore and Jowalapoor

Bridges

Bridges where they have appeared most prominently, of very small dimensions. The whole of these Bridges with the exception of those at the Aqueduct and at Nandode appear to me to have been somewhat hastily stuccoed, the outer coating of this material having been laid on before the arch had permanently settled and before the masonry had become perfectly indurated, ~~[illegible]~~

Having drawn attention to the Lowulla Jowar and Mungiory Bridges, I may observe that the defect in the former may be drawn from an accident which occurred to the right abutment and wing shortly after the work was finished. During the rains of 1850, flood water broke into the canal at the right upper stream wing, which it carried away. It is possible ~~[illegible]~~ that what with the shock of this accident and what with the torrent of water flowing into the canal at the back of the right abutment this part of the work suffered. The defects ~~[illegible]~~ are merely an extension of the openings to which I have before alluded ~~[illegible]~~ as not in any way touching the arch itself, and which in the present case have been very well repaired. In relieving the arches from the centerings the settlement was considerable as will be seen on reference to Table I of the appendix.

The Irwing [?] Bridge is the only one in which the voussoirs of the Arches are directly upon numerous centres, and whether from this cause or otherwise, the settlement has been more here than elsewhere. The lowering of the centerings of this Bridge which was the first constructed in the 2nd Division of the works, was superintended by Mr Bean in person, the result in the case of one of the Arches was unsatisfactory, the actual sinking of the crowns on the removal of the centerings was thus –

Right arch	3"·8"
Centre do	3'·77"
Left do	4'·52"

The two former stood the ordeal well, but on the left for a space of 5 or 6 feet across the Arch on the upstream side, cracks shewed themselves of sufficient opening to admit of a flat rule being pushed in to the depth of 6 or 7 inches. The bricks at the crown on the same side of the upstream face appeared too to have been crushed and disintegrated. Both the lowering and the striking of these arches were carefully looked after, but the Executive Engineer supposed that some careless brickwork had been introduced, and that in the absence of all supervision, the construction of arches of large dimensions with the inexperienced workmen with whom we had to deal, would be liable to annoyances of this sort. This Bridge was allowed to stand without its centres for 2½ months, on the completion of which time, it was concluded

that

Plumb

that any part of settlement was out of the question. Since the completion of the Stucco, since [illegible] have appeared in the plaster, it was over the haunches, where it is [illegible] there is no reason to suppose that any serious extension to these openings may ~~[illegible]~~ dispense the ~~[illegible]~~ of the work, in future they are of ~~[illegible]~~ no material importance ~~[illegible]~~.

[illegible] 2 and [illegible] the [illegible] sketches of these upper tracings of centerings, explain the unusual separations that took place in the haunches generally, reaching from the 6th to the 12th course from the skewback; whilst Plumb's centering the [illegible] arch that [illegible] used has in every case avoided this peculiar feature. In the latter centerings, the causes that [illegible] are shown for the separation at this particular part [illegible] are not clearly recognizable than those in the case of the Plumb centerings. In the [illegible] the separation distinctly takes place during the building, and due to the weight of the arch beginning to act upon the compressible material of which the centering is composed, no [illegible] the separation [illegible] occurs until the arch was keyed and the centering removed. In Table 1 which will be found in appendix, the amount of settlement on the removal of the centerings is shown for each arch that has been constructed. The action in these cases and the amount of settlement are clearly due to the nature of the [illegible] or [illegible] voussoir, the necessity of attending to which in its greatest measure here is a matter of very serious importance.

So in instance, the length of a
segment of a circle of 60° whose
radius is 33 feet, is 34.55 feet;
on examining this arch I find
that the number of courses of 3
inch bricks which have been laid
in voussoir ~~are~~ is equal to 126 - that
126 × 3 = 378 inches or 31½ feet, and
that consequently 3 feet in length
of the arch consists entirely of a
self compressible material. Now,
on [illegible] the average width
of joints on the whole [illegible] 1.285
inches. Whereas the width of them
with mortar as it is commonly
ground ought not to exceed ·25
or a quarter properly speaking
and with well cut bricks ·125
might be obtained.

All arches on the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] . ~~[illegible]~~, In a case that
came under my notice it would
the Government held was that it
was better to allow the native
engineer to follow his own ability,
[illegible] on experience
of the value of the material (See [illegible] vol 2 part 3 Chap [illegible]) [illegible]
with which he was working,
than to interrupt his progress
by the introduction of European
systems: a series of arches had
been built with [illegible] 3 inch
bricks, and with ~~[illegible]~~ mortar or
lime cement the latter somewhat
coarse, but ~~[illegible]~~ supposed to be of a good
quality for Hydraulic purposes.
Some of these arches were semi-
circular others were flat segments
similar to that described above;
the [illegible] in no
solitary instance under 3/4 in or
[illegible] generally speaking
they

they were about an inch, and the
was averaged ~~[illegible]~~ in [illegible] [illegible]
at 1 inch [illegible] [illegible] number of
2 inch bricks in [illegible] [illegible]
the arch [illegible] consisting of 100 rings
a total length of 2 feet [illegible] the
joints are, therefore, there were in
this case no less than 600 feet
in length of mortar, but is to
[illegible] of a matter [illegible]
[illegible] [illegible] volume
that the stability of the arch.
I may observe, and this is a fact
that was not considered by the ~~in the~~
builder ~~illustration above given~~) that the
native mistri have curious
[illegible] [illegible] the material
of which this arch is composed
is properly indicated; [illegible]
moreover, [illegible] to building
flat segments [illegible] [illegible]
[illegible] [illegible] [illegible]
arches [illegible] the [illegible], but
[illegible] The segment (which is ~~[illegible]~~
[illegible] copied from the English),
is ~~and~~ with the native mistri
semicircular, while of the more
[illegible] [illegible] upon which
the strength depends [illegible]
upon the [illegible] voussoirs
[illegible] the [illegible] of the
parts. The adaptation therefore
of the native style of building
without due consideration is
altogether inappropriate, and
the [illegible] it was then
[illegible] [illegible] of a
[illegible] passage [illegible] has
been built [illegible] the native [illegible]
[illegible] [illegible] native
[illegible] [illegible]
the [illegible] was [illegible] of
a few months utterly disfigured
by the [illegible] cracks [illegible]
[illegible] by the [illegible] alluded
to [illegible]

ties upon completely disintegrating
the mortar; the bricks actually
separated and dropped out, leaving
[illegible] the [illegible] of the arch.
[illegible] that [illegible] well [illegible]
formed bricks it is difficult to
[illegible] [illegible] of the [illegible]
[illegible], but it is [illegible] to
[illegible] [illegible] these bricks into shape.
[illegible] [illegible] as [illegible] could [illegible]
[illegible] which is the way
[illegible] getting out of the difficulty,
and [illegible] [illegible] would add [illegible]
[illegible] [illegible] [illegible], but it
[illegible] is an accepted
fact that [illegible] [illegible] [illegible]
[illegible] or [illegible]; in more than 3
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] with the
[illegible] of [illegible] [illegible]
of a [illegible] [illegible] any [illegible] irregularity of
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] with [illegible]
[illegible] [illegible] by [illegible] [illegible]
between the [illegible] [illegible] and
had [illegible] that [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
is quite [illegible] [illegible] [illegible]
[illegible] [illegible] without [illegible]. That
a reduction in the extent of
[illegible] be [illegible] by the [illegible]
[illegible] [illegible], I admit, but its
irregularity to [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] render its advantages questionable.

In the Ganges Canal works
the [illegible] attention, at the [illegible] [illegible]
[illegible] to a [illegible] [illegible] of the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible], and [illegible] [illegible]
[illegible] the whole of the works

on the Kali Aqueduct, as well as those in the Koradia as good specimens of close and, according to my ideas, well laid brick work. On the whole line of works in fact from Myapoor to the [illegible], there are few works that I would not produce as illustrations of ex-cellent brick ^facing ~~work~~. The ~~whole of the~~ bridges under this class are built ^faced with brick.

No 2 Class

The Standard of which is figured in Plate L of the Atlas.

These Bridges which are very similar to those above described, and principally differ in their having a segmental instead of an elliptical bed arch, are built in one continuous series from the 106½th to the 180th mile; they consist of 2 varieties of bridges, the leading ones having 3 bays of 45 feet each and those which are situated below having 3 bays of 40 feet each.

The works under this class may be thus enumerated

3 Bays of 45 feet each.

1 ~~Sirsowli~~ Pepulkera	8 [illegible]nowna
2 ~~Pepulkera~~ ^G. Raoli	9 Urnowli
3 Nidhowli	10 Mullipoora
4 Gancha	11 Mamun
5 Hisoolpoor	12 Uchurja
6 Sumnowla	13 Moondakhera
7 Pukhanna	14 Tukenda

3 Bays of 40 feet each

1 Daopoor	5 Karota
2 Birowli	6 Machowa
3 Gubtekla	7 Cumgari
4 Rasinpoor	8 Treka

making a total of 22 Bridges.

The two leading bridges at Ka²ote and Jotthaina were built under the supervision of Mr. Read the executive officer of the 2nd Division, the whole of the others were laid out and completed by Mr. Volk the Executive Officer of the 3rd Division of the works. The design is similar to that originally proposed with modifications adapted to the project of 1850. The introduction of Block kunkur in conjunction with brick is the most remarkable feature in this class of bridges. Block kunkur in fact may be considered the staple material for the whole of the buildings with the exception of the arches, which are invariably made of brick; brick too is used generally speaking in cornices and parapets, but not universally.

The arches of the Ka²ote and Jotthaina bridges were built on plain rubble centerings similar to those which under the section on centerings I have placed under the denomination of Class II A. Those from [illegible] downwards were built on centerings composed of external ribs of temporary brick work with an interior filled with earth, as shown under the head of Class II B. I have in the proper place given my opinion as to the value of these different sorts of centerings, it is only necessary to state, therefore, that they have with the exception of the two cases above mentioned been universally adopted in the build-

-ing

-ing of the Bridges of the 1st Class.

From the nature of the Centerings and the rigidity of the external ribs, which prevented the settlement which I have before alluded to, the separation at the haunches as shown so distinctly during the progress of the building of the arch, was less frequent here than in the cases above described. It was seldom observable until the Centerings were entirely removed, and then in a very slight degree; as a rule, however, after the construction of the parapets and when the arches were loaded to their fullest extent, exceedingly slight openings exhibited themselves in the parapets over that part of the haunches to which I have before alluded, the settlement merely showed that the same, and the same fault existed in these bridges as it did in others, [redacted]

The use of Brick machine burning throughout these works and its satisfactory appearance when the Bridges were completed renders it a matter of regret that they should be discarded. In cases

cases where mixed material had been used, such a coating was desirable, but in others as far as mere appearance was concerned the plain stone buildings would have been a pleasing variety. The texture of Kunkur, is honeycombed and as a rule not compact. In extremes the stone may be described in its most perfect state, as a grey semi crystalline rock, tough, with occasional amygdaloidal, or irregularly shaped hollows dispersed throughout its mass, the hollows being filled with earth. In its most imperfect state (I allude simply to the Block kunkur which is available for building purposes) the hollows are more numerous, and they give to the rock the honeycombed appearance to which I have before adverted. It is found in extensive tabular masses or strata (generally accompanied by sand) the upper and lower sides of which are slaty and apparently imperfectly indurated, the induration in fact increases towards the centre, where it is frequently of the hardest description as the [illegible] stone rocks, and of a crystalline character. In using this material there were a few indispensable rules to be attended to

1st The entire removal of the outside or slaty portion

2nd The placing of the masses in a horizontal position, and in courses corresponding with their laminae, or with that in which they lay in the quarry.

3rd In using the material at all, the greatest attention to be given by the Engineer superintending the works not only to the efficient quality of the material, but to seeing that the two former rules were abided by.

The outside was hewn off by the Quarry labourers in some cases, in others at the works themselves, heavy axes (Tool axes) were used for this purpose, and as far as my personal inspection admit of judging the 1st Rule has been strictly attended to; the chips or fragments removed from the blocks in preparing them for the building have been used as metalling on the Roadways. As far as such was possible the 2nd Rule was followed, and there is no doubt that the strictest attention was given by the Engineers to the quality.

From all, however, good well informed [illegible] was of works built with [illegible], it was very evident to me that from the nature of the material, and from its honeycombed texture, its outside surface required protection from the action of running water as well as from that of weathering. In the former case it was clear that stucco must be used, as the current would in a very short time remove the softer portions in the earthy particles, giving the outside exposed to the action of water a most unsatisfactory and dangerous surface. In the latter case where the work was not exposed to the abrasion of water, the very nature of the [illegible] calcareous

cavernous and rusticated in surface, and it particularly open to the effects of weathering, to the reception of seeds and vegetation of all descriptions to which buildings in India are subjected, and to both these evils being considerably magnified by the excess of moisture that will attend upon the introduction of irrigation.

I may observe that although I had no experience of the effects of attrition of current upon this species of rock, its use in buildings is so common in these provinces that there can be no mistake about its efficiency in the first place, and the action that weathering exerts upon it in the second, the latter is in direct proportion to the extent of the honey combed nature of the stone used, where this is in excess the surface assumes an appearance like that given to rusticated pillars and plinths, when loose bits of gravel have been stuck in mortar, when the rock was compact and crystalline it withstands the weather as well and better than our freestones and Oolites of England; in this case it is an admirable building stone. Its color is grey and therefore cold, which in a hot climate and under a broiling sun may be considered rather advantageous than otherwise.

In extensive works like those with which we were connected, it was impossible to draw very minute distinctions, and in fact the very superior class of kunkur which I have above described is so rare that it never existed uniformly in any particular work it was therefore determined that the use of

of the bridges whether built of kunkur or not should be stuccoed, and that experimentally the wing retaining walls connected with the Embankments, which were out of the reach of the Canal Channel should be left unplastered, so that hereafter an opinion might be formed as to the advisability or not of leaving kunkur surfaces exposed. All those kunkur works of the bridges as far as they are directly in contact with the water in the Canal Channel are stuccoed,* and I confess that there was a roughness and irregularity of courses about the kunkur, that had made me look upon the change with no great regret.

* Since this was written many of these bridges have been entirely covered with Stucco

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No 3. Class

The standard of which is figured in Plate LI of the Atlas.

The Bridges under this class are five in number, they commence immediately below the head of the Futtegurh Branch at the 54th mile, and with the exception of the Khudowli Bridge continue consecutively to the 70th. They are called

1 Lukheri Bridge
2 Jansut do
3 Turai do
4 Tutheri do
5 Utterna do

I have before described the cause in which the design of these Bridges originated. They are built exclusively of small native bricks which were procured from the extensive ruins at Chitowra and other places in the neighbourhood. To meet the insufficiency of this

this species of material, or 60° segments, the rise was increased to 10 feet, and to break the continuity of the surface given to the spandrils by this excess in the rise ~~[illegible]~~; the bridge roadway has been ~~[illegible]~~ supported on an open line of Arches resting upon the segments as open ribs spanning the waterways, by this arrangement the superstructure was reduced both in weight and extent. The sides were flanked by towing path passages.

These Arches were built on plain earth centerings, and from the nature of the brick that was used, and the consequent superabundance of Cement which it necessitated, the settlement on the removal of the Centerings, was considerable. Three of these bridges were [illegible] [illegible] after the masonry was completed and subsequent settlement has produced the same disfigurements in the parapet walls as I have mentioned ~~[illegible]~~ as existing in those before described. ~~[illegible]~~, the plastering of which was somewhat injudiciously [illegible]. The defect is more conspicuously marked on these bridges, from its appearance on the arches which occupy the spandrils. In portions of these works connected with the wings of approach, and the steps of descent which are attached to them, it was found necessary to substitute the large for the small brick; proximity of kilns to the [illegible] and [illegible] bridges especially rendering such an arrangement a matter of no difficulty. I have not been

at all satisfied with the results of building with the old brick. From their small size and frequently being in fragments, the proportion of cement is extraordinarily great, so that the building in mass consists of mortar in a proportion that exceeds all belief. A specimen of a wall which fell during the rains of 1832, presented a most unusual exhibition of this material. In addition to this, in itself a great defect, the ruins which were composed of brick laid in mud, although easily pulled down from the circumstance of the facility with which the bricks were separated, produced a material more or less covered with dirt and with all the care that was given by the Executive Officer, no washing could wholly get rid of it. An earthy substance in contact with the [illegible] was destructive to the proper [illegible] ~~[illegible]~~ of the lime cement ~~[illegible]~~ and was in itself, highly injurious. These two objects acting ~~militating against the value of the masonry and in comparison with that made of the new and larger sized brick showing that that built with the old is inferior to that built with the new~~ detracting ~~from~~ the value of the masonry showing that when constructed ~~with~~ [with] old bricks it is decidedly inferior [to] that composed of the new and [larger] sized kind, are merely pointed out by us as the results of our experience on these works. ~~[illegible]~~ The lime that has been used is derived from a very inferior

description

composition of Marle (called Earth Lime to distinguish it from that made from Kunker); the Bricks with which the ~~[illegible]~~ were built bricks were I believe very carefully selected, washed and laid, and so far as quality is concerned are of the very first description, as all the little bricks used by the Natives are. In both these respects therefore, viz: in goodness of Lime and quality of Brick, nothing could be better than the material with which these bridges are built but these good qualities are neutralized ~~[illegible]~~ in part by ~~[illegible]~~ want of bond, excess of mortar and introduction of foreign matter in the shape of mud into the masonry.

On this subject I may remark, that the presence of the ruins which provided the works with such an enormous quantity of material has been the main cause of our being able to complete such extensive works in so short a period of time. By singular good fortune, the Engineer might perhaps say, by a providential arrangement, these ruins were in the market in the only part of his District where good brick soil was scarce, and where fuel was (at a reasonable cost) literally not procurable; he found himself in the midst of plenty when on the brink of starvation, and neither he nor I can be much blamed for feeding on Manna in the wilderness, although such manna might not have been equal to the things on the rich man's table...

Mil, Obs!!

The standard of which is figured...

Plate LII of the Atlas

The Bridges under this class, commence at the 77th mile from that below Tordhanna to the Noorpoor Bridge or that situated at the 103rd mile, & are known under the following designation

1	Nanoon	6	Newari
2	Sutproora	7	Sounda
3	Pooth	8	Didowli
4	Sannikhoord	9	Moradnuggur
5	Nugla	10	Noorpoor

The buildings have towing path passages flanked by rusticated pilasters, with the spandrils pierced by cylindrical holes, in the respects they are quite, again the settlement of the arches which are segments of 60°, and which were constructed on plain earthen centerings was less here than elsewhere. I believe that the experience gained in building former bridges was partly the cause of this result, and at any rate the delay in completing the superstruction as well as that of covering the stones with stucco I have no doubt has been successful in diminishing [illegible] the disfigurements to which I have before alluded. In these bridges however, previously to the building of the parapet walls, [illegible] settlement of the haunches [illegible] itself in the crown of the [illegible] cylinders; the action [illegible] itself in these cases [illegible] separation, centrically [illegible] between the two haunches. The separation at this point was exceedingly small, but I draw attention to it, as a proof that settlement at this period of the progress of the building

was

was here as elsewhere prevalent. [illegible]. The whole of these works are built of new brick, and they appear to me to be the best constructed bridges on this part of the Canal. The brickwork in the arches was particularly good, and the seams were reduced to a minimum. The span of each arch is 50 feet in width, and the depth or thickness is 2½ feet at the Crown and 3 feet at the impost blocks.

No. 5 Class

The Standard of which is figured in Plate LIII of the Atlas.

An enumeration of the Bridges in this class will be found in the 2nd part of this paper, under the description of the Cawnpoor and Etawah Terminal lines to which they are entirely confined. They are quite plain with no other ornament than a cornice round the piers and cutwater heads, and a string course separating the parapet from the face of the building. With two exceptions in the Cawnpoor line where the span of the bridges has been increased to 35 feet, the maximum span is 33, and the minimum is 23 feet. Kunkur and brick have been used indiscriminately as one or the other was available; the latter being with the exception of the bridges at Akbarpoor, Bahosi, Jonabe, Oorunda and Suggut, nor

bridges

Bridges, were being applied to the construction of the Arches. The whole of the Arches of this Class were built on Centerings of Earth supported on each side by brick and mud walls on the plan noted as Class IIB: After the removal of the Centerings, the separation which I have before described, and which in fact has universally attended the removal of every Centering whether of Timber or otherwise, occurred I believe in all cases, and always in the same position, that is to say, at a distance of from 6 to 12 Courses of brick from the intrados. Whether such action appears to have depended greatly on the application of the upper structure.

The instances where Arches were built of Block Kunkur, the stone was of a very superior quality, and well adapted to all descriptions of building. In texture it was compact and crystalline and with hardly any traces of the earthy concretions which are characteristic of the Kunkur formation. Here, however, as elsewhere I have sacrificed the desire that I had to construct this stone as a becoming one for ornamental building, to the fear that was entertained of the joints giving cover to vegetation, and of the surface being injured by the action of the climate or disfigured by weathering. These Bridges have been coated with

Stucco

faced, in the same way as those which I have described under the head of Class No 2.

I have a few remarks to make on the Bridges, which as not conforming in Elevation and design to those legitimately answering to the Classes above-mentioned, have been separated and placed by themselves. These as will be understood from what has been before written consist of

1. Cross Bridge at the Kutmoo Works
2. Peeray Nulleeun Bridge
3. Sied anna Bridge.

and the single arched Bridges lying about the Terminal Works which may be thus denominated

On the [illegible] Terminal Run
[illegible]
Bunna
[illegible]

The Cross Bridge at the Kutmoo is in Elevation similar in many respects to that of Class No 1. Its arches are elliptical and described on the same number of Centres, but its Cutwaters are not surmounted by Pilasters. Circular headed niches, however, placed centrically over the Cutwaters, and dies sunk in the Spandrils, give it an appearance

not

not unlike that of the Class be-fore mentioned. The abutments of this Bridge are more massive than those of Class No 1. They are connected in their substructure with the under drainage of the Revetments.

The Puran Kulleea Bridge ~~the thole after Puran Aqueduct, was Stamped~~ the Design of which has before described, was completed about the time that I left the works, at this period it was without Stucco & altho' during the construction of the arches settlement in the usual form had occurred, the external [illegible] of the work exhibited no trace of it

The Sullimunee Bridge which was one of the earliest that was built, had its substructure laid out at a period long shortly after the work was thrown to drain the fen [illegible] the Action of [illegible], it was stuccoed, however, immediately after the building was finished. The design differs from that of No 1 Class merely by the introduction of Flank drainage [illegible] passages.

On the Campoor line the Bridges included in this list were amongst the first that were built, their completion and stucco were hurried forward, and the result is shewn in parapet disfigurements. -

The haunches in every case have been marked by a separation in the voussoirs, so exceedingly slight as to be un-observable without close in-spection

of action, but still existing in evidence of the action that has taken place. The defect does not appear to depend upon the sub-structure, but rather on a settlement of the crown of the Arch itself. In all bridges without reference to extent of piers or abutments, or to the nature of the soil in which the foundations are laid and especially where the superstructure over the arch has been hurried to completion, subsequent settlement has, although without any apparent increase to the defect above mentioned, shown itself by an opening of the parapet walls; this also to a very slight degree, the fissure not being traceable in connection with the Arch, but clearly I imagine depending upon it. I attribute the evil to the use of compressible centerings of the nature described in the leading section of this Chapter.

I believe that in practice when centerings are removed on the plan which I have described, and which is for the purpose of enabling the Arch to acquire its proper equilibrium at a period when the Cement is moist, and when such moisture admits of the most perfect compressibility, the separation at the haunches is if not universal, of such frequent occurrence, as to render it a matter of no consideration; the openings in

in fact become immediately closed and the joints from the settle-ment of the Brickwork, and the softness or moisture of the Cement, attain a degree of fine-ness as also of uniformity, that could not be attained by any other means. It becomes a question, however, in how far such settlement may be due to the yielding of abutments either by their turning on the base as a fulcrum; from the compressibility of the material of which the abutment is built, or finally, from the slipping of the horizontal courses of Masonry of which the abutments are composed.

Now with regard to the 1st point, or "the actual yield-ing of the abutment itself"; it will be seen by referring to my first rule for bridge build-ing that the intervention of curtains and floorings to the bays, prevented the abutment from turning on its fulcrum or base line; where timber Cen-terings were used, these floorings and curtains were universally built before the arch was relieved from its centerings; in other cases they were absent. Whether however, they were present or absent the separation at the haunch took place; the action, therefore, in the arch appears to have been uninfluenced by this circumstance. Again, in cases where

when the extent of the Abutment and its excellence of workmanship placed all probability of yielding out of the question, the separation at the haunches seemed to prove indubitably that the action arose simply from the settlement of the crown, and without reference to those parts of the structure on which the arch rested. As I have taken much interest in the progress of these buildings, and have lost no opportunity of examining the impression that this action of settlement exerts on the intrados of the arch or on the work generally, by endeavouring to detect cracks or marks of separation in the one, or a want of perpendicularity or disarrangement in the other; these observations having been especially directed to those bridges where the structure had been finished, and the disjoints of which would necessarily exhibit the smallest possible defect.* I may remark that the cases where I have observed

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* With the exception of the bridges which were built at the commencement of the works, viz. those at Kuttahal, Jowalapoor, Mungloura, [illegible], Jogulpoor, Dunah, Badra and Bhopra, to which either struts or [illegible] were subsequently added, the Bridge arch abuts continuously upon a long line of wall which extends to a considerable distance both up and down stream on each side of the arch. The face of this wall is perfectly smooth and even, so that were the thrust of the arch to affect its abutments, action on the face of the wall would be inevitable, and could not escape detection. In a settlement that took place in the Dhunowri Road Bridge, the settlement was marked by a separation of the wall on the upstream side, a slight way

observed traces of action on parts of the building in the region of the Skew backs are exceedingly rare, and of a nature leading to great doubt as to their origin.

In the instances of the Dukheri and Surai bridges which come under the head of Class 3 where the building material is of old native Brick, the inside of the Towing path passages next to the Waterway shewed slight traces of action in an horizontal separation of the plaster at a point just above or corresponding with the extrados of the Main arch and its impost block; the separation was sufficiently distinct to attract my attention but the trace was exceedingly small and confined to the passage itself. Evidence appeared to be offered here of the thrust of the arch having affected the masonry.

In a case of a single arched bridge of 30 feet span Class No 5 at the village of Barra similar horizontal separations took place in both the side passages, extending more or less over the extrados of their Arches; in this case the separations were more distinct than in those before described although

They

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way, above the point where the arch abutted on it. In no other case amongst the numerous Bridges which have been built on these works, has this action been in the slightest degree shewn.

they were entirely confined to the region of the passages themselves, here, however, the soffit of the main arch shewed a hair line dis-tinguishable on the stucco, distinctly continuous, but not trace-able beyond the intrados. Evi-dence of action was here again manifest, and the trace on the soffit of the main arch, was in all probability dependant on the action exhibited on the side passages.

In all these cases the defect may have arisen from the quality of the masonry. The very questionable nature of the cement used at the Barra bridge and the unquestionable thickness of the Beams, much acted on by [Salts], appeared to me to account for the separation described at the Barra Bridge.

9.93

(27. J. & p. 3.2)
Barnett

The nature of the soil in which the foundations of the 3 arched bridges at Dubheri and Surai were laid was sand, that at Barra was of an inferior description. No abutment sink-ing or disarrangement could have taken place from the reasons stated in the foregoing note; and although it is possible that the Centre piers of the 3 arched bridges may have tilted, there is no evidence of such having taken place, nor do I think that such is probable.

The actual vertical set-tlement

-ttlement however, of the sub-
-structure of the bridges extending
from Roorkee to the 110th mile
is by no means an impossibility
It universally rests on sand,
and in some cases as it will be
observed by reference to the plans,
is embedded in the natural
forming level surface. Traces of
4 such settlement could not,
however, escape detection.—
With regard to the
2nd point, or "the compressibility
"of the material of which the
"abutments and substructure
"are composed" in how far the
settlement of arches may act
on the thrust backs it is not very
easy, but it is clear that com-
-pressibility in that reason must
depend entirely on the nature
of the masonry. When this
is of brick compactly laid in,
with narrow seams and joints
of mortar, and allowed per-
-fectly to indurate, the masonry
must be proof against any
force that arches of our dimen-
-sions could exert upon it. On
the other hand, when the masonry
consists of badly put together
brickwork, or of kunkur either
of inferior quality or of uneven-
-ly squared blocks, in which
cases the joints are necessarily
either large or imperfectly filled
with mortar, the compression
of the material is by no means
an impossibility. Add to the
above evils, a want of indurat-

is added, the thrust exerted by an Arch would inevitably affect the Abutments. At one period of our Bridge building Kunkur was used in the imposts blocks, and the whole thrust of the Arch was exerted on Masonry made of this material; this was corrected afterwards, and the best brick masonry was substituted for that of Kunkur; the use of the latter being confined to those parts of the work on which a dead vertical weight was exerted; the change was made from the possibility of Kunkur impost blocks being liable to compression from the causes which I have before enumerated, but there is no evidence of their ever having acted injuriously, or of settlement to the arch having taken place from their use. —

Of the Masonry whether of Kunkur or of Brick of the Bridges above described, was laid in with all the care that it ought to and which to the best of my belief it has been, on all occasions; compressibility although sufficiently acting on the arch itself on the removal of the centerings, and up to the period of the induration of the Cement with which it is built, could not have extraordinary influence on the rest of the building. —

The 3rd and final [illegible]

question to be considered is "the slipping of the horizontal courses of masonry". In the northern Division of the works where stone lime and Soorkhi as a compound are used for the purposes of mortar, and even where the Earth Lime, which I have elsewhere referred to as of a very superior quality, has taken the place of stone lime, the evil to which I am now addressing myself is one that can hardly be anticipated, certainly only in such cases where the thrust of the arch has been brought to bear on an imperfectly indurated mass, and such from the period to which the substructure has been invariably allowed to stand previously to the giving of the centerings, has not been the case with the knowledge of the supervising Establishment. In the Southern or lower Divisions the lime is not equal in quality to that which is used above, and in some cases from the coarseness of the ingredients which have been mixed with it, especially the Bujree or fine Kunkur gravel, the thickness of the seams exposes the courses of brick or Kunkur to greater chances 161
of slipping than would have been the case had the mortar been of a finer consistency, or had the seams been thinner. In a case of a useless building

by a Contractor, we had an [illegible]hibition of this evil, but with this exception in which the arch fell as will be described hereafter, no bridge that has been built shews the smallest sign of action from the slipping of the courses of the masonry. I confess, however, that had I been prepared for the thickness of seam that has in some cases shewn itself from the use of coarse mortar, I should not have placed the Towing path passage in such close proximity to the waterway. It is from this contingency alone, and not from any objection to the design otherwise, that I have throughout these pages recommended, as a general rule, that the Towing path passage, and the waterway of the Bridge should be separated by a distance of 2 feet plus the width between the waterway and the point of intersection between a tangent to the extrados of the main arch and the flooring of the passage.—

In the construction of the numerous bridges which has taken place during the last six years under all sorts of contingencies, it is gratifying to find that in two cases only accidents have happened. Both of these cases shew in a remarkable degree, the evils of inattention to the proper

use

use of mortar in seams, and are curiously illustrative of the questions discussed in the foregoing paragraphs. The two exceptions to which I refer took place in the building of the Dimah and the Bhosan Bridges, the former under Class I and situated at the 32nd Mile of the Main Trunk, the latter under Class 5 at the 14.5th Mile of the Cawnpore Terminal Line.

In the 1st case, the arches 55 feet span were built on timber centerings with material of the very best description, and under the eye of an Assistant Executive Officer. The arches were keyed as usual, and the process of striking the centerings commenced. So great was the quantity of mortar used that the arches literally followed the centerings in their gradual depression, and had the timber work been entirely removed would have fallen to the ground. This was prevented by their resting on the frame work. After the depression had proceeded to an extravagant extent, ~~when~~ the masonry was pulled to pieces. At the period when this occurred I was too far off to visit the spot, but I directed the assemblage of Engineer Officers in Committee to report on the cause of failure. The Presidents report is sufficiently interesting to

give it admission into the Appendix, where it will be found marked **K**.—

The results were arrived at without demurrer; the Abutments were sound and not disarranged in the slightest degree; the accident had occurred simply from an overabundant use of mortar in laying in the courses of brick work in the arch.—

The 2nd Example occurred in a small single arched bridge with a span of 30 feet, the only bridge on the Ganges Canal works that had been entrusted by an Executive Engineer to a Contractor; the Contractor however, was overlooked by a Native Sub Assistant Civil Engineer. In this case immediately the Centering was removed, the left impost block with its superstructure and forming path passage in its rear, slipped away and the arch fell to the ground. This was a direct and unmistakeable case of "slipping of horizontal courses of masonry." The Abutment below the slipping surface was uninjured, and as this was an especial point of the inquiry, I may observe that no trace of yielding or action upon it in the slightest degree could be discovered. On examining the causes of this accident, it appeared that that part of the abutment on which the impost block rested, was literally made of rubbish.—The Executive Engineer

of

of the Division reported " the
"cause as it appeared to me of
"this accident was solely the very
"bad quality of the Masonry in
"the backing of the Arch, and"
"in the great quantity of Mortar
"used, and in the very inferior
"quality of this Mortar" It ap-
peared that this Contractor had
only built the Arches and their
backs, the substructure having
been completed by the Subassistant
Civil Engineer. In addition to
the Contractors bad work as leading
to the failure above described,
the masonry had not been
allowed a sufficient time for
induration.

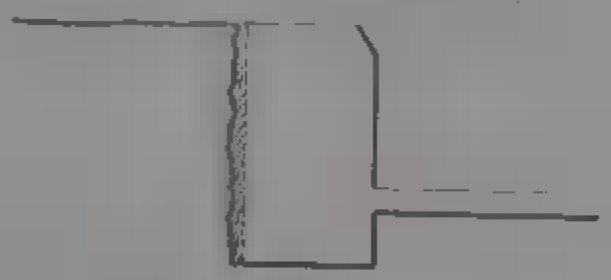
The Bridge at Brosan
is one of a series built under
great difficulties of resources,
and a want of material which
placed the Executive Engineer at
his wits end. The Abutment
walls of the Bridge in question
have no counterforts in their rear,
they rest upon the original soil
which in all this part of the
Canal is of the compact and
retentive nature that I have
before described it to be. Diagram
CXVII, fig 2. of this Chapter is an
exact representation of a section
of these Abutments shewing the
position of the Towing Path
passage, in the present case
unsupported by masonry walls
but imbedded in a soil I should
say as incompressible as Ma-
-sonry —

It is perfectly evident however, that the value of this method of construction and design depends entirely upon the Abutment being placed in close approximation and in direct contact with the virgin soil, and that if a hairs breadth of space is left between them, the abutment becomes isolated, and is no longer in dependance upon one of its elements of support. Again in making Excavations for foundation walls, the Masonry must rest upon the virgin soil; excess of excavation refilled by loose earth so as to bring the cubic content of work built on a par with that of the Estimate, there is nothing more dangerous and detrimental to the Stability of a structure than that before alluded to; and yet in works under the management of European Overseers I have had [illegible] to notice cases in which both the above errors had been committed. In closing this section therefore, and in addressing myself to men of the above class, I shall repeat in the words of one of my circulars "I would here draw "attention to the necessity in excavating foundations to dig "the Earth as closely as possible "to the true dimensions of either "foundation wall, Abutment, or "retaining wall that comes in "contact with it; if a narrow "space is left between an abutment and soil, the former

becomes

"becomes isolated and derives
"no sort of benefit from a con-
"tact which is intended to be
"of the utmost service. For
"instance taking the following
"diagram of the Abutment
"of a bridge; if the space
"marked in shade is a hollow,

Diag CXVIII



"or only loosely filled with earth
"the masonry derives no aid
"whatever from the soil, and the
"abutment loses all the advantage
"in its opposition to the thrust
"of the arch which it ought pro-
"perly to derive from being
"backed by a rigid mass. This
"hollow space ought in no in-
"stance to be allowed, and if
"the excavation is greater than
"the width of the abutment the
"whole of the space excavated
"ought to be filled with masonry.

"The same remark applies
"to depth of Excavation for
"foundations: when this has been
"carried to excess, the whole ought
"to be filled in with masonry:
"to use loose or imperfectly
"rammed earth is tantamount
"to ruining a building. —

"The use of abundance
"of water in running in brickwork
"is as indispensable to the goodness
"of work as thinness of seams of
"mortar and thinness of plaster to

its

its durability"

In concluding this Chapter, I may observe that it has been an object in all the designs of Bridges as well as of works in general which are connected with the Canal Channel to accompany them by means of access to the water. In cases where Revetments are required such Revetments have been commonly designed in the form of Ghats; Rajbuha Heads are universally protected in front by lines of this species of stepped Revetment, and to the whole of the Bridges, with very few exceptions, Ghats or flights of steps have been attached. At those Bridges which are crossed by the leading and high Military roads of the Country, or at those which are situated near large Towns or leading places of resort, very extended ranges of Ghats have been appended, so that Travellers and Foreigners who come in Contact with the works of the Ganges Canal may appreciate an undertaking which has been designed for the benefit of the general community, as well as for that of the Agricultural population in its neighborhood. In designing the Ghats whether at Bridges or elsewhere, my intention has been to open them to the free and unimpeded use of all, whether travellers, or village people, to whom they will offer the greatest of all luxuries in an Indian Climate - bathing:- and to the Hindoo population the greatest of all possible advantages in this world - access to Gunga Mai. —

CHAPTER. IV.

Works of Accommodation

The object of these buildings is to provide accommodation to the supervising Officers in their progress of Inspection, and to the Establishment in charge of the works, the water course heads, and the Irrigation. –

They have been designed on plans which are figured in Plates LIV and LV of the Atlas, and consist of two species of buildings, which are denominated 1st and 2nd class "Chokies", or in plain English "Sta-tion Posts".

The 1st Class Chokies, have a centre room 20 feet square, with an enclosed verandah round it of 10 feet in width, the verandah being divided off into rooms with porches on two sides which open into the Centre with which a room on the 3rd side is connected; on the 4th side a separate room is devoted to the accommodation of a subordinate, in the event of the centre room being occupied by the superior. The rest of the verandah accommoda-tion is for the purpose of store rooms and places of residence for the Canal native Establishment.

The 2nd Class Chokies are similar buildings, without the verandah or outer inclosure, their dimensions properly speaking, were designed at 18 feet square. on which they have generally been built: in some cases, however, this has been reduced to 18' × 14', and in others increased to 21 feet square

The

the latter in cases where the attach-
-ment of an outer verandah, so as to convert the building into one of the 1st Class, has been contemplated. These buildings are for the residence of the Chokidars and Native Estab-
-lishment, and for the protection of tools and Stores.-

The whole of these buildings whether 1st or 2nd Class, have flat roofs; the object having been to avoid as far as possible, the con-
-tingencies of fire, to which thatched roofs are liable.- They are with few exceptions built of refuse material, that is to say, of the half-burnt bricks which remain in kilns after the works directly connected with the Canal Channel had been completed; the cementing ingredient is mud; both externally and in-
-ternally, however, they are stuccoed or plastered with Lime Cement.- In the language of the Department of Public Works in these Provinces, they are built of "Kucha Pukka" brick and mud, the brick being what is called "Pilla" or half burnt.-

Their position relatively to the works is uniform; this is on the left or roadway bank, on the upstream side of bridges; at a distance from the edge of the water of not less than 100 feet, and from the Bridge ramps not less than 100, or more than 300 feet.- Their floorings are well raised from the surface of the Earth, in no case less than 1 foot, and in the South-
-ern divisions where the Country is flat ~~[illegible]~~, as well as in other parts of the Canal where dampness is a characteristic of the Country the plinths of the Chokees have

been

been laid on a level with those of the pillars and parapets of the bridges to which they are attached. As a general rule these Chokies are well raised and the accommodation is free from all the inconveniences to which similar buildings have been subjected on the Jumna Canals, from the want of elevation. -

In cases where 1st Class Chokies have been built in connection with falls and Locks, their situation is centrical between the main and Navigable Canals, and on the up stream side of the road that connects the Bridges which have been built over the works.

The general position of these buildings has been determined with reference to the supervision of the Rajbuhas or watercourse heads in their immediate vicinity; and their position relatively to the bridge, viz. on its upstream side, has been selected, that advantage might be taken of the prevalent direction of the winds which during the dry season would blow the dust on the bridge ramps away from the Choki, instead of towards it, a consideration of no little importance to the convenience and comfort of the residents in the Choki. —

The 1st Class Chokies, have been built all the way down the line of the Canal and its branches at distances of about 12 miles, or ranging from 12 to 15 miles apart. the Specific object for which they have been built, and on which their distances from each other, have been determined, is to keep up an open line of communication from one end of the works to the

other

other, to afford the means at all seasons of the year, for either Inspecting or Executive Officers, to visit at the shortest notice any point of the works which requires his presence, and to relieve both the Government, and the supervising Establishment from the evils and inconveniences which during the rainy months, might arise from difficulties in marching and moving, were no accommodation of this sort provided.

With the above object in view, it will be clear that these buildings are not intended as private residences or for the occupation of the European members of the Establishment beyond limited periods. Permanent residence, or occupation for lengthened periods would evidently defeat the object for which the buildings have been erected, the chain of open posts, by which the maintenance of a connected line is contemplated would no longer exist, were even one of these buildings occupied by a family, or by an individual whether connected with the Canal Establishment or not; and considering that the purposes for which the Government has been advised to erect these buildings are entirely of a specific nature, the conversion of the accommodation which they provide to objects foreign to the intention on which they were built, can hardly be too rigorously protested against. The rule that has been usually observed on the Jumna Canals with reference to Chokie occupation, is that the parts of the building which are expressly intended for the Commissioned and non Commissioned Staff,

Under

should be reserved for their accom=modation; but, that in the absence of the former, the Non Commissioned Staff may use that part of the building which is intended for the superior grade on certain conditions solely appertaining to protection of property and cleanliness of occupation. Juniors in either grade are supposed to give way to Seniors, and unless under specific orders in writing no individual is expected to hold residence beyond 2 days. In every case it is expected moreover, that people who take advantage of the accommodation should consider themselves answerable for the property; for the glass in the windows, and for the general preservation from injury of the house and its appendages.

The case is one, however, upon which it is impossible to lay down determinate rules; — heavy repairs during a period of the year when a European is called upon to move out to a distant Choki, may detain him for an indefinite period as a resident in one of these buildings; in such a case, the building could hardly be considered as turned from its legitimate uses. Heavy work, or matters connected with Revenue might detain either the Director or any of the Executives for an equally indefinite time at one of these Chokies; under such circumstances a continued oc=cupation would be perfectly fair. The object being understood it appears to me to be sufficient to carry it out according to its true spirit, abiding as far as possible

by written Rules which emanating from the Directors Office, would be the code for general guidance.

These rules ought to be hung up both in the Centre room, and in that one in the veranda occupied by the Non Commissioned Staff, of every 1st Class Choki; and the Chokidar or Chuprassi in charge ought to be made responsible for the furniture, glass, doors windows, and the state of the building generally, reporting the dates of arrival and departure of every person who occupies the building; and noting the way in which the property has been treated. Unless stringent rules are laid down for the prevention of injury not only to the glass, furniture and wood-work, but to the stucco and walls of the building (laying aside the carelessness and indifference with which Government property is treated in some instances by people who ought to know better) the servants attached to our Establishments whether private or public are frequently the cause of a wanton destruction to property, when such property does not belong to their masters. It is necessary to prevent this, and it can only be prevented by active legislation. –

The ground in the neighborhood of these 1st Class Chokies ought to be kept in order, clean, neat, and free from deformities of any description; above all things its drainage ought to be properly attended to, full conveniences being provided in the outlet which is attached to the sluice works, and which is situated

ated in the Choki yard. In all
cases however, I would look upon
this Inlet as a secondary means of
relief; if possible, and in regard
to inclination of the natural slopes
of the country, and a spacious
Channel ought to be excavated so
as to carry the drainage water not
only away from the Choki yard
but away from the Canal altogether.
It will be understood from what
I have said elsewhere in these pages
that the object of the Inlet which
is attached to bridges, is to relieve
the country from the water ob-
-structed by the interposition of the
Ramps of the Bridge, and by their
interference with the drainage
of the country. —

The proximity of the [illegible]
are fruit plantations which is in-
tended to be an appendage to
every 1st Class Choki, may be the
means of adding greatly to the
convenience as well as to the ap-
pearance of the Station. Under
an Officer who takes an interest
in the order in which his division
is conducted, and in the state in
which his buildings and their
dependencies are maintained,
the 1st Class Chokies and their ap-
pended plantations are really
most desirable places of resort;
in exemplification of which
I could point out Stations on the
Eastern Jumna Canal ~~which
have been~~ established by Mr.
Deputy Superintendent Brew
of the Canal Department, and
which, without any additional
outlay, and merely with that
natural attention, which is de-
-rived from the possession of a
large development of the bump

of order; are equal in neatness and tidyness to the most carefully watched private property.—

The Area of ground appertaining to 1st Class Chokies is equal to about 4 acres.—

The 2nd Class Chokies, are with a few exceptional cases (dependent on the absence of Rajbuha Heads) built at every Bridge on the line of the Canal and Branches, their position is similar to that of the 1st Class Chokies and the elevation of their floorings above the level of the country has been fixed on the same rules that guided me in the larger buildings. These Chokies are expressly for the accommodation of the Chokidars in charge of the Irrigation, as well as for the tools and stores of which there are depots at every post; the main ones being at the 1st Class Chokies, and the subordinate ones ~~[illegible]~~ under charge of the Chokidars at the buildings now under review. Independently of the control of the Irrigation, the works in the immediate neighborhood are under the charge of the Chokidars and the position of the building relatively to the different works, with the means of cross communication afforded by the Bridges, give him every facility of access to both sides of the Canal and, consequently, the best means of supervision.

To the 2nd Class Chokies situated above the Ranmoorh no separate ground is attached, their site is within the Canal boundary, and their limits are marked by the boundary ditch.

Be—

Below the Narora Fork and on both the Cawnpore and Etawah Terminal Lines, where the Canal boundary is more limited in extent, extra ground has been taken in, so as to regulate the position of the Chokies with reference to the Bridges agreeably to the rules before described.

I have described the Chokies as built of "kucha pukka" or of half burned and refuse bricks with mud; this method of construction originated in the Jumna Canal works, and was adopted with a view to economy; it was perpetuated on the same grounds in the works of the Ganges Canal, where in addition to any advantage that might be derived from the measure as one of economy, the demand for well burned bricks was so great, and in many situations the difficulties of procuring them in sufficient abundance for the works that had necessarily to be built with the very best material, was so notorious [illegible] Executive Officers were put to every [illegible] shift to procure material at all. In devoting the [illegible] of half burned bricks to the building of Chokies therefore, we adopted a plan that expedited the completion of these buildings, and at the same time disposed of a species of material, that would otherwise have been useless, or at any rate have been a dead loss to the Material Department.

The Estimate of 1850 for Chokies built on the main line

and the 2 Branches into which it is divided at Nanoon, with the material above described, is in itself a very large item, the total amount called for, for the construction of buildings of this sort including both those of the 1st and 2nd Class, was as follows

1st Division	11445	4	1
2nd Do.	13341	3	3
3rd Do.	14621	11	5
Total cost of Buildings on the Main Canal	44408	2	9
Cawnpore Branch	38328	8	11
Etawah Do.	43136	14	2
Total cost of Buildings on the Branches	81465	7	1
Grand Total on the Main Canal & Branches	125873	9	10

At the period when the above Estimate was drawn up, the evil of using the half burnt bricks in that part of the building which was in connection with the soil, and liable to injury by the effects of moisture, had been prominently brought to notice, throughout the whole extent of the Canal. In those Districts lying to the south, where the soil was impregnated with the reh or alkali to which I have before alluded and where the bricks which had been made of this soil were of a very uncertain quality, the materials had so completely failed, not only by the attacks of moisture, but even by the mere weathering of climate, that as far as the foundations or that part of the building terminating on the plinth or flooring was concerned, it had been determined in all cases where such could be done, to use a better description of material, and to reject the use of pilla brick entirely. This although a good determination in

[illegible] was not brought into practice until the greater number of the buildings had been completed, and even then in some cases, the absence of good brick, necessitated the Executive Officer to recur to the use of the inferior material. Latterly however, the use of the half burned or refuse brick has been confined as much as possible to the superstructure.

With regard to the use of Mud as a Cementing ingredient the defects appear to me to be great, and necessarily increasing in proportion to the thickness of the seams; to the quantity of Cement used, and consequently to the size of the brick, and to the care with which the brick laying is executed. Lime Cement indurates, and is not liable to the effects of pressure after this induration has once taken place; Mud Cement on the contrary although it hardens in dry weather, gets soft in the wet, and during that period of the year when the rain is continuous, and when everything exposed to its influence is affected by moisture, the Mud cement in imbibing this moisture becomes liable to the action of superincumbent pressure which must tend gradually to the disarrangement of such walls, especially when such walls have the weight of a roof upon them. The consequences of this disarrangement are exhibited in unequal settlement of the walls, in the declension of doorway arches from their impost blocks and in a distinction to the [illegible] of the roof. Cheap, [illegible] [illegible]

may be, when constructed on the kutcha pukka principle, they are undoubtedly subject to the above evils, and although in nine cases out of ten careful supervision and the use of the large class of brick reduces these evils to a minimum, they must always be unfavourable over a building where the material in all its parts is not equal.

However, the following cases substituting lime for mud cement, at a very considerable excess of cost, but with a view of testing the value of this original outlay with that arising from the constant repairs to which the kutcha pukka Buildings are liable. In the 3 cases the following [illegible] were built with [illegible]

[illegible]	[illegible]	Jessopur	[illegible]	1713 4 11
[illegible]	do do	Moondakhar	[illegible]	1696 0 3
[illegible]	do do	Nawabgunj	[illegible]	1,120 14 9

These station posts were built in the cold weather of 1851/52.

On the Etawah Branch the following buildings have been constructed on the same principle.–

Estimated Cost mud Cement	Material		Police Station	Material		Actual Cost Lime Cement
[illegible]	[illegible]	[illegible]	Pitthya	[illegible]	[illegible]	[illegible]
361 13 0	do	do	Koosearu	do	do	472 2 11
361 13 0	do	do	Lonya	do	do	521 4 8
361 13 0			Sowajpoor	do	do	488 10 2
[illegible] Total				Total		[illegible]

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It will be observed that in the Etawah Communications kunkur has been used in some cases in the foundations only, in others in the whole building; the appearance of the Chokies built with kunkur is exceedingly good, the color is cold but it harmonizes well with hot weather feelings arising from an Indian climate. ~~[illegible]~~ Where this material has been used in the superstructure, stucco has been laid aside.

A comparison between the Estimated and actual cost of the buildings above specified, as shown by the tables, will give a clue to the amount of original outlay, that the use of kunkur would have entailed on the Government. Whether such an outlay would have been warranted, is a question that must be tested hereafter, by the results of the annual repairs on the buildings constructed on the different systems, the excess of cost in the one being taken into consideration.

It would appear from the above tables that to have constructed the whole of the Chokies with kunkur instead of mud the excess of cost would have been as follows.

For the 1st Division

[illegible] = 3050..5..11 (excess)

For the 2nd Division

[illegible] 43136 [illegible] 5766..7..5 = 13632..6..0

The cost of Kucha Pukka as used in the Choki buildings varies considerably, the maximum and minimum rates of each Division being as follows:-

1st Division	maximum	Rs 12..0..0	per 100 cubic feet
	minimum	" 7..8..0	" "
2nd do	maximum	" 8..1..6	" "
	minimum	" 5..12..3	per "

3rd Division	Maximum	Rs 9. 0. 1 per 1000 cubic ft	
	Minimum	4. 4. 8 ½ per	"
4th "	Maximum	10. 4. 10 per	" {[illegible]}
	Minimum	5. 0. 7 per	"
5th "	Maximum	9. 10. 0	" {[illegible]}
	Minimum	6. 3. 3 per	"

Wherever well burned bricks have been used, a note to that effect has been made opposite the rate, and this is a circumstance to which in drawing comparisons, most especial attention is required, the cost of well burned brick varying from 6 to 16 Rupees per thousand, whereas the cost of the Peela, or refuse ones is only 2 or 3 Rupees per thousand.

In conclusion I may observe that in the course of progress, improvements and, in some cases additions have been made, to the 1st Class buildings. In all the Divisions excepting the 2nd the veranda roofs have been raised an additional foot with the object of improving the accommodation and making the rooms cooler. In some cases and I much regret that it was not been done in all, a staircase has been made from the floor to the roof, so as to give easy access to it, and during hot weather

the means of approach to the upper terraces the elevation of which affords a very agreeable and airy promenade during the close and sultry evenings of the hot weather.

In the 2nd Division, or that extending from the 26th to the 110th Mile, the Chokies have been constructed precisely on the same design as regards elevation as that originally estimated for. As a set off however against the economy of constructing the verandah roofs as has been done elsewhere, ~~the~~ the Executive Engineer has built to each 1st Class Chokie a range of flat roofed outhouses containing 2 rooms of 10' × 8' each. The object of these buildings is to prevent either the European or Native Establishments from disfiguring the neighbourhood of the [illegible] with huts and temporary buildings the erection of which is in all cases prohibited. During the progress of the works, and it is during this period that the whole of my Directorship has been passed, it has been found necessary to allow the construction of temporary huts for the accommodation not only of the labourers but of the Supervising Establishment. Our 1st Class Chokies have in many cases been built at points far ahead of the excavation and works in progress so as to act as [illegible] and Head Quarter Stations to the Establishment both European and Native in charge of the advanced work; These advanced [illegible] necessary as they were at the time not[illegible]

exist on the completion of the works for which they were expressly made, and ought therefore to be summarily abolished. It appears to me to be so desirable that the ground in the neighborhood of these chowlies should be maintained in a neat and orderly state, that if the plan adopted in the 2nd Division of having a range of outoffices attached to each chowlie were found leading to such a consummation, I would strongly advocate its extension throughout the whole of the works.

CHAPTER V.

Works of Navigation

[illegible] chapter [illegible] ~~divid~~ into three sections.

I. Navigable Channels
II. Do. Roads
III. Do. Locks.

[illegible] road [illegible] connected with each other to a [illegible] separation. [illegible] navigable canal [illegible] [illegible] passage [illegible] [illegible] canals [illegible] would not be constructed in [illegible] designs either be consistent with the objects in view nor be in [illegible] to the cultivator ~~[illegible]~~ of Irrigation.

There is a medium [illegible] in which both objects may be gained, we may dispose [illegible] on a regimen capable of [illegible] acting the [illegible] which either in a [illegible] or [illegible] climate would inevitably attend upon [illegible], and we may by [illegible] attached to the [illegible] [illegible] provide ample way for the passage of boats.

The [illegible] works which are [illegible] for Navigation come under the above category. The channels [illegible] its [illegible] [illegible]

approaching or emerging to the passage of boats, the openings to the [illegible] which are [illegible] by the [illegible] descents are [illegible] by lines of safe and commodious transit, which [illegible] in a [illegible] direction and at considerable distance from the main channel are placed out of the influence of the rapids. In these circumstances the difference of level is gained by lockage, and every convenience is afforded to the passage of craft both in facilitating [illegible] and in providing [illegible].*

The navigable line under [illegible] which the more important object of irrigation imposes upon the Ganges Canal, will afford the means of water carriage from the point where the main canal leaves the mountains throughout the [illegible] Doab; it will [illegible] the present [illegible] at [illegible] a compact and safe line of transit to the avoidance of the shoals and rapids which are the characteristic features of the main River.

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* When the falls for regulating the levels of the bed were constructed in the Eastern Jumna Canal, a channel on the left side was [illegible] with gates for the purposes of lockage; the plan was [illegible] attended by no interference with the object for which the falls were built, and it demanded the mere application of upper and lower gates, which if required [illegible] might easily be removed; with the exception however of the locks in the southern Division where the body of water was comparatively small, and [illegible] the working of them [illegible] on the [illegible] of the [illegible], none of these locks [illegible] used. The [illegible] arising from the proximity of the lock channel to the [illegible] and the fear of being engulphed in the latter may possibly be the cause ~~[illegible]~~ of the non-acceptance of the Eastern Jumna Canal as a line of [illegible] carriage. The [illegible], if there is [illegible], is by [illegible] on the Ganges Canal [illegible].

River; by its junction with the Jumna near Humeerpoor and Kulpi, a new link will be furnished to the water carriage of the country; and as I have remarked elsewhere, its elevated position to all the Rivers that run parallel to it, provides the means of still further extending its usefulness, by the adaptation of locked Channels, and by these means connecting the inland Towns or commercial marts with the navigable rivers.

I have drawn attention to a Navigable branch that might be constructed from the main Canal near Moradnuggur to the Hindun River, as well as to one that might be taken from the Boolundshuhur Branch near Bulasfoor to the Jumna River; both these lines would give the Government [illegible] [illegible], the former having the disadvantage of having to navigate the tortuous course of the Hindun River, the latter being more altogether confined to artificial and [illegible], compact lines. Both of these open out new lines of Country to which the means of water carriage would be an acceptable, and both of these, I think, are perhaps worthy of consideration. By looking at the map however it will be evident that there is no limit to the means provided for the adaptation of the Canal to water roads, and to their being linked on to the side Rivers. The Rajbuhas even in themselves will I doubt not become the medium of providing the Inland villages with hill produce, especially with the smaller class of rafter for house building ...

is now unattainable from the cost of land carriage.—

Before entering upon the detail of construction and design of the different works to which this chapter is devoted, it will be necessary to explain the especial objects by which I was guided in their elaboration. The changes that have taken place in the disposition of the works in the Plan sufficiently account for the disposal of the Channels for navigation; to the works, therefor, that have actually been built, I shall confine myself, and these with the complement ~~of~~ ~~locks~~ above noted, far similar in general respects to those in the table Estimate.—

In the design for the Navigable Channels I was guided by the following considerations.

1st The necessity of an alignment at a sufficient distance from the works on the main Canal to prevent either one or the other from being incommoded by too close proximity.

2nd To place the point of departure of the navigable from the main line at such a distance from the Falls that it might be entirely free from their influence.

3rd To protect the head of the navigable Channel, and to make the best arrangements for securing the safe admission of craft.—

4th To adapt Corn Mills to the waste channel of the Locks, and to make it generally applicable to the purposes of machinery.

5th To combine with the masonry works attached to the Locks,

such

such Inlets for drainage, and such outlets for Irrigation as might be required from that particular part of the Canal in which the works were constructed.—

The dimensions of the Channel as well as those of the Lock chambers were determined on the length of the largest sort of Kurrie or rafter into which the Saul timber of the Forest are cut up for the convenience of markets. This species of wood which varies from 10 to 15 feet in length and from 3 to 6 inches in scantling, is drawn in enormous quantities, and is in general use throughout the North western provinces wherever it can be obtained at a reasonable price. It is collected at marts situated on the banks of the great Rivers in the neighbourhood of the forests, and from thence it is floated down on rafts to Depôts, from whence it is distributed over the Country. The Kurries of 15 feet are laid side by side and formed into articulated rafts frequently of immense length, but in width confined to the length of the Kurrie. By making the Navigable Canal Channel therefore, equal in dimensions to the section which I have shewn in Diagram
121 CXXI and by designing the lock chambers in a width of 16 feet, I gave every facility to the passage of the same species of raft which now traverses the Main Rivers. I avoided the necessity for alteration in the form of rafts, and I did not demand any change in the method to which the boat people and raftsmen have been accustomed. — By

a length of 100 feet in the clear to the Lock chambers the size of raft which will be able to pass down the Canal will be equal to the average of those which are now floated down the Ganges. The width is a convenient one and admits of the utmost simplicity in the gate and sluice apparatus.

The question of the greatest importance after the dimensions of the channels and Lock Chambers were designed, appeared to be that which comes under the 3rd Item; it was very clear that to consider the main line as a navigable one, with the prospect of boats or rafts being brought in contact with the Falls, was unreasonable. It mattered little whether through carelessness or accident boats were overwhelmed in these Cataracts catastrophes of this sort were to be avoided. The notorious ~~indifference~~ incapacity of native boatmen was well known, the carelessness and neglect of Establishment were contingencies of too frequent occurrence to be treated with ~~im~~ in-~~punity~~ difference, and the possibility of raft passing the navigable road, and proceeding onwards towards the Falls was obviously a matter to be guarded against. It was a case in which no half measures would answer, and one in which the prevention of danger ought to be so certain, that no conceivable contingency should [illegible] to defeat it.

The original idea was to throw Chain booms over the main Canal immediately on the down stream side and below the head of the navigable channel. The

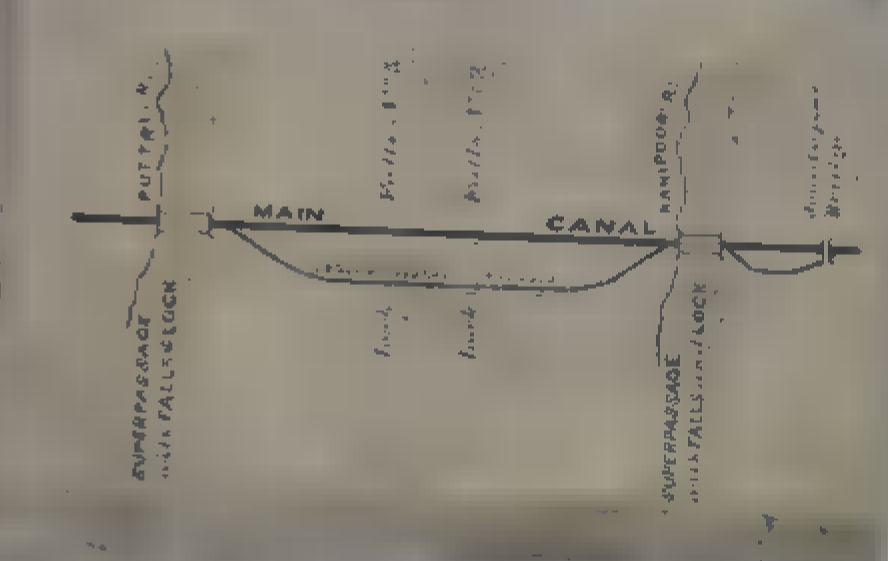
objections to this plan, however, were the uncertainty of obstruction that booms would offer, especially under the extreme variations of high water level to which the Canal was subjected; there was much in the practical detail, moreover, of the design, that rendered its adoption inconvenient, and the mere facts of doubts existing as to its sufficiency appeared to me to be fatal to a project upon which the security of property, and even of human life depended. For a line therefore of Chain cables suspended across the main Channel, a bridge of boats has been substituted; the passage of traffic therefore, is entirely confined to the open Channel above the bridge which acts as a finger post in directing the boats to the navigable canal head, and opposes a direct bar to the advance of craft beyond the limits of safety. The Bridge itself although not designed as a high road for communication affords the means of crossing the main channel and of placing the Canal Establishment in connection with the Rajbuha Head which is situated on the right embankment, and on the upstream side of the bridge. The Bridge, moreover, will to a certain degree act as a bund, by retaining the water on the upstream side on somewhat higher levels, give to both the Rajbuha Head on the right bank, and to the navigable Channel on the left, the advantages attendant thereupon.

The works under this design offer a security to boats in their passage which otherwise they would

of I have had, the chances of accident are indefinitely removed and the advantages arising both to Irrigation and navigation appear to me to be conclusive as to their fitness for the purposes required.—

I now proceed to the detail of the navigable lines and the different works therewith connected.— In their order of precedence those in the Ganges Khadir will be first described, and to do this satisfactorily I must introduce a repetition of Diagram XIV, Fig. which was formerly given as illustration of the change that has been made in the disposition of the works between the Ranipoor and Puttree Torrents.

Diag: CXIX



The object of the navigable channel in the Khadir is to overcome a descent of 36 feet that occurs between the Ranipoor and Puttree superpassages. The distance between the two works or between the two extremities of the high and low lines is only 4·6 miles; it was considered, therefore, expedient to design the whole in one uninterrupted channel for navigation, instead of in a detailed series appropriated to each particular descent. The navigable channel accordingly

which leaves the main Canal on its left bank immediately on the upstream side of the Towalapoor Bridge, runs parallel to it, impinges on the superpassage at Ranipur under which its channel is carried; and from thence gaining its parallelism, meets the main Canal below the Puttri superpassage under which its course is conducted on the same design as that at Ranipur. —

The Towalapoor bridge acts towards the head of this line of Navigation, in the same way that the bridges of boats before described are intended to act at points where there are no masonry bridges. It offers a marked and decided limit to the water available for navigation; it is far removed from the head of the Falls, and by occupying each bay which is 35 feet in width by 3 boats anchored, and firmly held in position, so as to prevent the passage of craft beyond its limits, we shall secure our object, with the smallest possible interference and with as little obstruction as could well be, with the passage of the water in the main Canal.

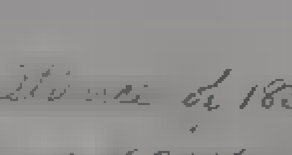
The head of the Navigable Cut — consists of an arched masonry channel 20 feet in width, giving cover to a towing path of 5 feet, and a water channel of 15 feet in width; this channel passes obliquely through the bridge wings and ramps leaving the main Canal at an angle of 40 degrees. Drop gates are fitted to the front, so as to admit of the channel being laid dry for

-trains or for other contingent causes, and the entrance into the arched Channel is ~~covered by~~ flanked by masonry walls with piling and the necessary expedients for protecting the work from injury. The whole forms a component part of the Dowallapoor bridge to which it becomes a leading feature on the upstream left flank, the remaining three flanks being covered by the "Dalhousie" Ghats.-

The work with the exception of the foundations and the more lofty parts of the abutments in which boulder masonry is used is constructed entirely of brick. The arch, which is a segment of 60° is sufficiently elevated to admit of free passage for loaded boats with a maximum supply of water in the Canal; (see Atlas Plate XVIII Fig. IV)

After leaving the masonry head above described the Channel which is excavated in a soil somewhat sandy and on the following section

Fig. CXX.



proceeds for a distance of 1830.66 feet on a curve with a radius of 2256 feet. It is then carried for 4868 feet parallel to, and at a distance [1000, of] from the Canal boundary until it reaches the neighbourhood of the Rampoor supply passage immediately in front of which the 1st series of locks is established. At a distance of [illegible] feet from the upstream

face of the superpassage works, a revetted and floored masonry Channel, 16 feet in width, directed upon the works in a ~~segmental~~ curve ~~form~~, delivers the water on the head of the Lock Chamber. This masonry Channel which commences im-:mediately below an octagon har-:bour or resting place into which the navigable Channel is directed, is entered under a masonry bridge with a segmental arch (60°) of 25 feet in width, 9 feet of which is occupied by a towing path. The Channel then sweeps round a 1st Class Chokie which is situated in an elevated position on the right, and between which and the channel access is gained by a flight of steps, and proceeds in-:wards. On the approach to the head of the Lock, this masonry channel throws off a branch running parallel to it, and passing under the floorings of the superpassage, in the same way although on a higher level than that of the navigable line. Both these Channels form flank archways designed uniformly with those for the passage of the water in the Main Canal, from which they are separated by a masonry revetment. The Archway for the navigable line is 19 feet in width; and that for the parallel passage which is intended for the supply of Corn Mills at Bahadoorabad is 10 feet. Both the supply heads of the Corn Mills and the passage for boats are thus brought to bear upon the Ranipoor superpassage, of which they form component parts. The

floods of the torrent passing over the whole, without in any way interfering with their respective channels.

The height of the Revetment or wall that separates the navigable passage and the Lock Chamber from the main Canal Channel is 15½ feet, the width giving space on the side towards the main stream for a parapet of 3 feet in height. The difference in width between the Lock Chamber which is 16 feet and that of the archway under the superpassage in prolongation of the Lock Chamber which is 19 feet in width, has enabled one to terminate the Revetment of separation above described by a flight of steps, connecting the higher with the lower levels, and giving access to the navigable channel under the archway.

For the purpose of regulating the supply in the Channel 3 Sluice openings of 6 feet in width have been placed through the separating Revetment, at a point immediately above the head of the Lock Chamber.

For the general design of the Locks themselves with the detail of the apparatus for opening the gates, filling and emptying the Lock chamber, I am indebted to my predecessor, and to my Inspection of the works of this description in Lombardy. There can be no difference of opinion on the extreme simplicity of these designs which will be better understood by reference to the Atlas, Plate XXIII.

The upper Gates which are comparatively small being in height 8½ feet, are held in position by a plain

wooden cross, in the place of the complicated collars: and the lower ones for the retention of which in their proper position greater care is required, are immoveably fixed by a timber laid transversely across the chamber, capping the upper pivots of the gates, and having its ends embedded in the Masonry work; by embedded, it is not meant that the Timber is irremoveably built into the Masonry, it is merely laid in grooves adapted to its reception, and out of these grooves it can be removed and the gates displaced, without the slightest disarrangement to the building. In both the upper and lower gates the lower pivots are seated in the usual way in Stone blocks, in the present case the blocks are all the [illegible] [illegible] work, they are in fact corbels from the ruins of Old Delhi. —

The Stone Corbels were first in an upright position then used as bumping Stones for the gates to shut upon; this plan has been adopted universally in the now of the unbroken use both in England and Lombardy which it was supposed would lead to interruption in the working of the gates, by collecting sand deposits. —

The Sluices for filling and emptying the Chambers, the simplicity of which attracted my attention when on the Pavia Canal more than anything else that I observed on the Italian Canal works: are really exaggerated stop Cocks, that is to say solid cylinders pierced through on one

side, so that when the side that is pressed is opposed to the chamber, water escapes; by turning the cylinder and opposing to the water the unpressed side, the sluice is closed. From the shape of this machine which is cylindrical and measuring 2½ feet in diameter by 3½ feet in height, we have for want of a better called it a "drum sluice"; it is worked by an upright axle which is carried up through the revetment and is then worked by a handle or lever fixed at right angles to it. As in the case of the lock gates its lower point works upon a stone block (vide Atlas Plates XXIII Fig 4). These sluices are fixed on a low level, so that when the admission of water into the chamber is required every advantage is derived from head pressure and by this to rapidity in filling the chamber.

The ease with which these drums are worked, their utter independence from all rackwork, or crows, in fact from all vertical motion, renders them of extraordinary value on works which are entrusted to the charge of simple and uneducated establishment. I may remark also that the adaptation of complicated machinery, or simple machinery even, which is liable to disarrangement, might be fatal to the use of works of this sort, in the absence of means for its immediate repair.

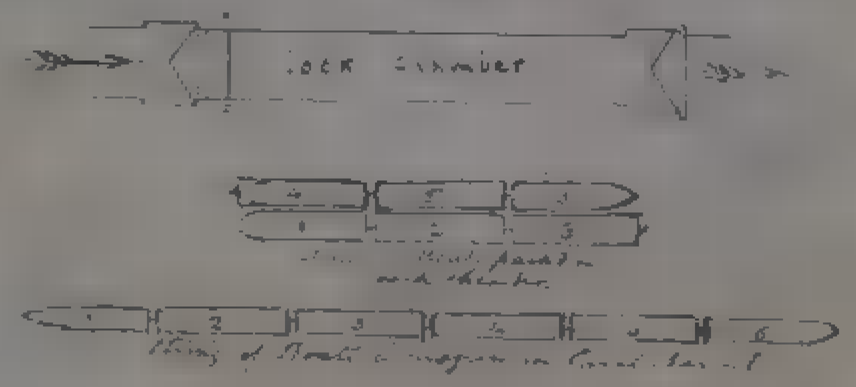
A question, however, still remains, dependent in a great measure on the horizontal movement which appears to be so

ad[illegible]

admirably adapted to security. Many of the sand and silt deposits which are to be expected in the Ganges Canal works affect the working of these sluices? Even this evil, however, should it occur, may perhaps be remedied by a standing order for turning them twice or thrice a day, should the locks be out of employ.—

The dimensions of the Lock Chambers are 16 feet in width on a total length of 110 feet, the drop being 9 feet in perpendicular height with a [illegible] at its foot. The width is adapted to the larger sort of Kutti [illegible] of 16 feet in length, used in the craft which is used on the Ganges as before explained. It is also adapted to a string of boats as proposed to be used for the transport of materials on the works, the design of which is shewn in the following diagram.

Diag. CXXI.



String of Boats [illegible] in Canal [illegible]

I have adopted the Venetian apron as shewn in the diagram at [illegible] X, for the purpose of keeping the boats clear of the drop, and for breaking the fall when water is permitted to pass over in large volumes. This apron is used in all the lock chambers that I visited in Northern Italy, and its advantages were so highly spoken of by the Engineers with whom I [illegible]

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-nied me, that I have no doubt, time and practice will prove its applicability on the works in these provinces.

The whole of these buildings are with the exception of the more massive parts of the Abutments and foundations which are of boulders, built entirely of brick masonry; the lining out of the curves of approach to the supply passage has been admirably executed by [illegible] the Assistant Engineer in charge of the works, and the brick laying and work in general ~~has~~ have been well done.

On leaving the supply passage a masonry channel carried on [illegible] a similar to that on which the navigable line reaches the work, drains the water on an escape channel which runs on the left [illegible] parallel to canal at a distance of 531 feet from the main canal boundary. The length of this ~~[illegible]~~ curve and of the masonry channel from the down-stream face of the supply passage to its termination on the Earthworks is equal to 415 feet. The above masonry channel, the Revetments of which are two feet in height, is crossed by an Aqueduct for conducting the mill supply which up to this point runs parallel, although as it will be understood from the purposes for which it is intended on a much higher level.—

Shortly after the masonry done in connection with the supply passage is left, the main canal channel is widened out

out into an Octagon reservoir for the purpose of acting as a harbour and resting place for boats on their reaching the Lock passage. At a distance of 4140 feet in advance, the Bahadoorabad Mills which lie on both sides of the navigation channel, are passed under an Aqueduct; and in advance of these again at a distance of [illegible] feet above the Locks the Bridge over which has its axis in prolongation of that of the Falls Bridge over the main Canal, a method of alignment which has been designed for all the works connected with navigation —

The works at No. 2 Locks consist of a Lock Chamber with its dimensions and fittings on the same plan as those before described. On the right of the Lock Channel is a waste one 11 feet in width to which the necessary appliances for regulating the Escape water have been attached. Both Channels are crossed by Masonry segmental arches, forming a bridge with a roadway 25 feet in width between the planks of the parapets. The Lock and the waste Chamber are separated by a wall which gives a platform on its top of 19 feet in width. On the down-stream side this platform is terminated by a flight of steps affording the means of approach to the water from the bridge roadway. The side or abutment Revetments are terminated both on the up and down stream extremities by

sweeps

sweeps which are well covered by the slopes of the excavated Channel.—

An open line of Canal in prolongation of that before described, delivers the water on No 3 Locks the position of which relatively to No 3 Falls on the main Canal is uniform with that before described. With the exception of the bridge roadway which is 15 feet, the works at No 3. Locks are similar in every respect to those at No 2.— Their dimensions and design are identical.—

At a distance of 600 feet, the excavated Channel returns its parallelism to the main line of Canal, running at the Puttri Superpassage preserving the same condition as regards alignment and works as it did on its approach to the Ranipoor Torrent.

The curved Masonry Channel which is ~~608¾~~ 599½ feet in length from its commencement to the upstream face of the Puttri Superpassage is entered under a Masonry bridge similar to that at Ranipoor; the Channel sweeps round a 1st Class Lock which is situated in an elevated position on its right, the higher platform being connected with the water by a flight of steps: the Lock both in its position and appurtenances is precisely the same as that at the Ranipoor works; the only difference that exists being that the Lock Channel delivers the water into a Channel of 25 feet in width

instead

instead of into one of 19, and that consequently the revetment separating the navigable from the main Canal is 13½ instead of 7¼ feet, and the height of Steps 9 instead of 3 feet. – The difference in the design of the Works in the above respect is purely accidental. At the Ranipur works we were restricted within limits bounded by the Inlet and outlet that had been previously built. At the Puttri works we were unshackled; we had, moreover, at the Ranipur works to arrange for a passage for the Inlet water for the Bahadurabad mills, a necessity that did not exist at the Puttri works, where with the exception of the Archway required for the purposes of the Navigable Canal, the work was devoted entirely to the passage of the main stream.

On passing the lock, the boats are delivered on the lower levels into the main Canal. They have in the 4 Locks already passed, overcome a descent of 36 feet. From the tail Channel therefore of the Puttri works the Navigable Canal is absorbed into the main stream down which the boats proceed without any further interruption until they reach the high land of the Doab.

The Channel and Lock works at the Puttri are entirely built of brick masonry with the exception of portions of the most massive parts of the structure in which boulders have been used. This in fact is the character of all the masonry

works

works attached to this line of Navigation, externally they are stuccoed or covered with a coating of Lime Cement.—

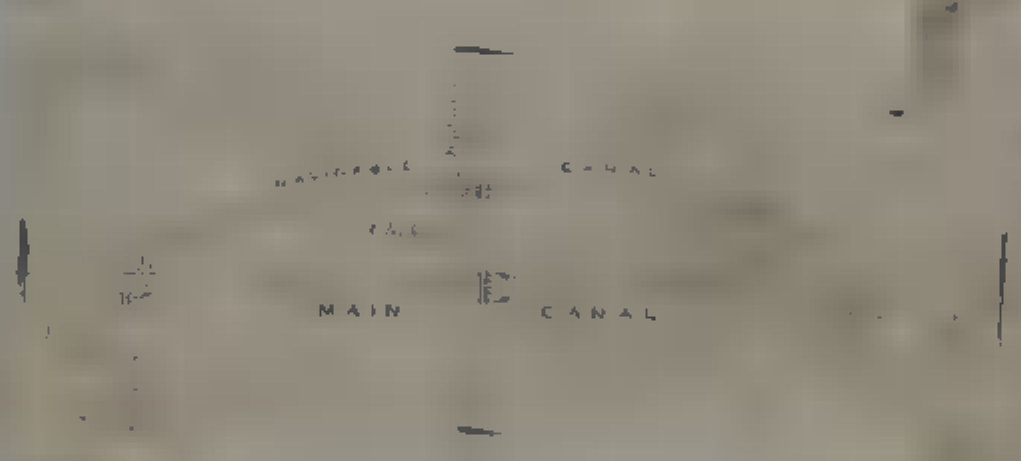
From the head at Dowalla-ipoor down to within half a mile of the commencement of the Masonry Channel at the Puttri, the excavation of the channel and foundations for the works were not incommoded by Spring water, and were therefore executed without the slightest inconvenience. The whole of the works connected with the Puttri, however have been laid in Springs, and have been built under difficulties of no ordinary nature.

The former were constructed under the management of Mr Kay and the latter under that of Mr Login, the Assistant Engineers, to whose care the whole of the works on this part of the Rhadri have been intrusted.

From the above description it will be understood that the Locking in the Rhadri is confined to the tract lying between Dowallapoor and the Puttri, and that in this distance the Channel for navigation continues uninterruptedly and in a course entirely distinct from the main line of the Canal.—

We now come to the passage of the Falls which lie below Roorkee, or those on the high land the description of which is given in the 2nd Section of the 1st part of this history. Here in contra-distinction to that above described, the navigable passages are carried round each descent separately and they are necessarily ... conformity

accompanied by works of a similar [illegible] of different description. The preceding Diagram will shew in detail the relative positions of the navigable and main lines of Canal and the different works attendant thereupon, under the design which I am now about to describe.



Diag CXXII

On the above plan the passage of all the falls [illegible] below those at the [illegible] is effected. These works are 11 in number and range from the Asofnuggur Falls which are situated at the 20th mile, to those at [illegible], the last of the series, which are built at the 184th mile from the Regulating Head at Myapoor.

The relative situations of these works will be shewn by the following table, which exhibits in a parallel column the Amount of drop which the change of level necessitates at each of the Falls which are appended to the different works

	Situation in miles	Amount of Drop
Asofnuggur Falls	20th mile	8 feet
[illegible]	31	8 "
Belra	42	8 "
Jauli	48	5
Chitowra	55	8
[illegible]	65	8
Bhola	94	8
[illegible]	106	8
Palra	129	5
[illegible]	164	5

The reasons why the Navigable Canal was not carried in one continuous line, and parallel to the main stream as has been done in the [illegible], were the length of the whole distance between the head and the foot of the descents; the great quantity of valuable ground that would have been occupied, and the expense that would have been incurred, not merely in additional bridges for cross communication and in the excavation originally required but in the after maintenance of such an extended channel. On the other hand there were many great recommendations in favor of the continuous line; the [illegible] of the cuts which with their boat bridges and apparatus attached are expensive items in the charge of these works, would have been reduced from ten to two; the inconveniences which are anticipated from the filling up of the mouths of the navigable cut heads would have been reduced in a similar proportion. And there can be no doubt that an entirely detached passage would have been more secure for the transit of boats and rafts than the main channel; but it must be taken into consideration that the excavated line of the navigable cut would under these arrangements have either required to be of greater capacity or it would have been fitted with numerous harbours or resting places, which like sidings on railways would have been necessary for

for the free and uninterrupted passage of boats and rafts moving up and down stream. In balancing the advantages and disadvantages of both methods I determined on that which has been adopted, and although it would be a source of regret to find my anticipations of its benefits unrealized; I should have the satisfaction of knowing that the method I have rejected is still available simply by extending and prolonging the cutters channels.

In the works of the [illegible] connection with the attached Falls which I am now about to describe, the line AB formed the axis or the centre of the bridge of communication across the Falls and Rocks. From this axis the entrance and exit of the navigable channel are fixed at 3500 + 4000 feet respectively from the head and tail of the falls, a distance that was supposed to be adequate to removing these points out of the influence of the rapids. The main and navigable Canal are 1000 feet apart from centre to centre, and they are connected at the entrance and exit by dams, as shown in the sheet of the Atlas in which the detail of projection is given — The alignments therefore form an Island, of which the length is 7500, and the breadth 1000 feet. This inclosed tract is used for Plantations, and as the site of the Choki (in most instances a 1st Class one) which is centrically situated between the navigable and main Canal, and on the

upstream

upstream side of the road that connects them.

The head of the navigable canal consists of a uniform Revetted passage 16 feet in width, the left Revetment meeting the Earthwork by steps and in some cases by flights of steps. The right, or that which constitutes one side of the inclosed angle between the two streams is connected with a similar Revetment, which forms the other, resting on the left of the main Canal. These 2 Revetments the one forming the Right of the entrance into the navigable Cut, and the other that of the left flank of the main Canal, meet each other at their ends in similar steps, the whole building forming a V but narrower at one end than at the other, that end which is narrowest being salient towards the stream.

The Revetment which faces the main Canal is fitted with Iron rings framed in three tiers, which correspond with similar appendages, attached to a Revetment wall on the Right of the main Canal.

Between the two Revetments a bridge of Boats will be thrown, held in position by chains fixed to the rings, and by screw poles adapted to openings in the Canal bed.—

The object of the 3 tiers of rings is to accommodate the bridge to the fluctuations in the rise and fall of the water, and the Revetments to which the rings are attached, are designed with flights of steps on the upper 6 feet of their height so as to give the means of approach to the bridge roadway under these fluctuations.

Attached

Cummins

Attached to the upstream side of the revetment on the right of the main canal, is a Rajbuha head. The connection between the two works has been formed in a variety of ways adapted to the particular position of the work. In some cases by flights of steps or Ghats, in others by a mere con-tinuation of the walls.

[illegible]

The passage into the navigable canal is an open one, without arch; it is fitted with grooves and the necessary apparatus for shutting out the water, including the supply of the planks or sleepers necessary for this purpose being used in the interim as a temporary means of communication across the passage. A travelling or moveable platform might with great advantage be adapted to this passage.

I may observe in closing the description of these headworks that a flight of steps is constructed at the distant end of the building which separates the two streams by which means access is given to the upper platform of the works and to the column at the point of separation of the channels.

The detail of the Boulsand apparatus for fixing the bridge in position is left for future de-termination and adjustment, practice and experience will I have no doubt render this part of the design a simple one. In the meantime I have adopted the Iron open boat in present use on the canals in these provinces, the dimensions of which are

L 30½' X B 9⅔' X D 2½'. Seven of these with intermediate platforms will be required at each of the heads from the Assofnuggur to the Dasna works. The Bridges at Pulra & and Jewna where the Main Canal is reduced in width, will not require more than six boats each. I have preferred boats to pontoon cylinders, because the former are available for all sorts of useful purposes whereas the latter are limited to one. By using the same sort of boat in the bridges that is used (droppers etc) in the canal generally (vide Diagram XXXI) for the transit of goods, there would be less fear of interruption in the event of repair. These Bridges, moreover, might be considered as the hospital for any which had seen better days, and whose time might be more valuably spent in retirement than in the active duties of its purpose.

The Locks and ~~the~~ waste channels are identical in every way (excepting in height) with those that I have before described, as built at No 2 and No 3 of the headings. The depth of the Revetments ~~vary~~ varies with the theoretical maximum high water mark in the canal, for instance from Assofnuggur to Dasti where the maximum high water is 11 feet from the canal bed, the Revetments on the upstream side of the lock are 11 feet. But from Dostowna to Dasna inclusive the theoretical depth of the water being 9 feet, the height of the Revetments ~~are~~ is 10 feet. At Jewna and Pulra where the depth of the water is 5 feet, the height of these Revetments is 6 feet only—
only

By adding to the above mentioned heights the amount of drop on each Lock, the depth of gate in the lower Chamber may be estimated. The following Table will shew this in detail.

	Upper Chamber		Lower Chamber	
	Height of Revetment	Height of Gate	Height of Revetment	Height of Gate
	feet	feet	feet	feet
1. From [illegible] to [illegible]	11	10	20	19
2. From [illegible] to [illegible]	10	9	19	18
3. From [illegible] to [illegible]	9	8	18	17

With the above exception the works as far as Lockage are concerned are identical.

At the No 2 and No 3 Locks on the [illegible], I have terminated the flank Revetments on the upstream side by sweeps into the bank. In those which I am now describing these Revetments are prolonged upstream, that one on the right forming the front to a series of [illegible] Corn Mills, that on the left terminating in a [illegible] Road. The arrangements will be best understood by reference to Plate XXIX of the Atlas. I have, however, for the present restricted the number of mills (the Punchukkies of these Provinces) to four for which 2 houses are built. The Revetment is of a length however sufficient to admit of a third house adapted to the same number of Punchukkies, for which all necessary arrangements have been made, by laying out the dimensions on an uniform scale with the basement levels of the houses, and by building Inlets for the mill shoots, which for the time being, are filled with brick work. The Inlets of these mills

become

leave the Channel on the high levels, the water being retained for the purpose by the regulating Shutter at the head of the waste Channel. The tail or escape water passes away on the lower levels.—

This waste Channel is converted into a receptacle for the surplus water that falls on the Island and in the neighbourhood of the mills the water is received into a well and passes into the Chamber by an underground Channel on the same plan as has been universally adopted in the Ganges Canal works

In occasional instances when the Inlet drain above mentioned is insufficient to relieve the Island from rain water another work on the same plan has been constructed on the down stream side of the Locks as shown in the diagram at S, in this case the front towards the water is occupied by a flight of steps

The Excavated Channel is on the same plan and of the same capacity as that described in the [illegible] of which a Section is given in Diagram CXX.. The left bank forms the road and plantations as are described elsewhere. The details of Earthwork with 2 exceptions which I shall describe presently are as a general rule precisely the same as those on the main Canal.—

On the whole of these works a perfect uniformity of design has been attempted. With regard to [illegible] of gates there are three different [illegible] as shown by the [illegible]; in other respects, every design [illegible] in one work is identical with that of the other and consequently the fittings which are adapted

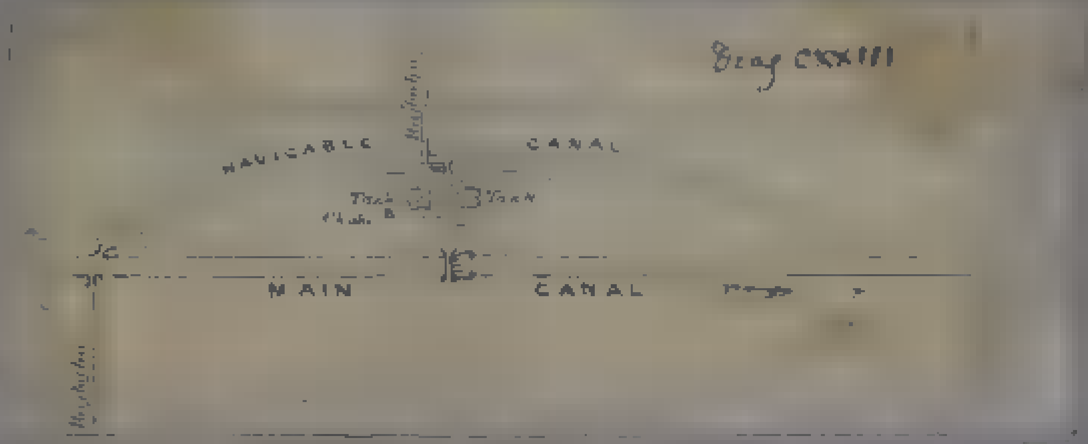
adapted to one are adapted to all. The advantages both to the supervisors and to the works themselves of an economical arrangement of this sort are too well known to be dwelt upon with any extraordinary emphasis; they have, at any rate, been attempted to be carried out in all the designs of the Ganges Canal works, where varieties of dimension have been reduced to the smallest possible limits consistent with efficiency.

The two exceptions to the uniformity of detail in the earthwork before referred to, are confined to the Navigable Cuts at Muhmoodpoor and Bhola.

At Muhmoodpoor the alignment has been retained in all its integrity, but in effecting this the channel came in contact with a good deal of low ground, a jheel or hollow of some extent was intersected, and for a considerable distance the true level of the bed was above that of the surface. It became necessary, therefore, to embank that part of the channel which was connected with the low ground, and to make such arrangements for procuring earth for that purpose as would lead to the least disfigurement to the land in the neighbourhood. The following diagram will shew the disposition of the works at Muhmoodpoor, the site of the tanks or reservoirs from which the earth has been taken to form the embankments, and the abnormal position of the 1st class bridge dependent on the irregularity of the ground and the [illegible] form

1029

by the navigable cut.—



I consider that these

Reservoirs a necessary evil, they have been retained within the smallest possible limits, by measurement calculated on the required demand for earth; they have been dug as deeply as economy would admit of, so as to reduce as much as possible an area which will necessarily become a field of reeds and water rushes. and everything has been done to render this nuisance as innocuous as it possibly could be. I am not without hopes that occasion may be found hereafter for filling in these Reservoirs should their existence materially affect the health of the station; this may demand a summary remedy, but it is possible that the clearance of the navigable Channel of silt and sand deposits may in the course of time provide material in sufficient abundance, for disposing of this evil without any necessity for special estimate.—

At 13th old the variations from the general design are dependent on the village which is situated within a short distance from the Canal boundary. It would have been necessary either to enclose the village in the island, by carrying the navigable Canal around

vend it, or by making certain modifications in the alignment to keep clear of the village altogether. To have brought the village within the boundaries of the Canal would have been as annoying to ourselves as it would have been inconvenient to the inhabitants, we could not even by doing this have maintained the alignment in the same form, the navigable cut would have been carried on a very extended circuit to meet the requirements of both parties and laying aside the additional expense, the advantages appeared to be in favor of the modified course in which the village would meet with no interference. The plan therefore of the Bhola navigable Cut has been laid out as represented in the following Diagram.

Diag. CXXIV

Diag CXXIV

From a to b the Channel has been widened out into a harbour for boats, which is a convenient appendage to the navigation, and the earth which has been excavated from it has enabled us to equalize the surface of the ground in its neighborhood, and to complete the embankments of the main Canal which would otherwise have been imperfect.

In the construction of the masonry appendages to the works of

the

the navigable lines which I have thus described, bricks have been invariably used with some trifling exceptions in the foundations at Talawar, Beola ~~and~~ Dasna, Pulra & Simra where the proximity of Kunker Quarries has enabled us to adopt that material to the more massive parts of the structure. At the above places Pulra excepted ~~also~~, the tail foundation walls have been laid upon blocks sunk to a depth of 12 feet a necessity arising from the surface of spring water shewing itself within the limits of the projected foundations. With the exception to the ~~three~~ four instances above mentioned, the works have been laid in dry soil, and have been constructed without any difficulty. The works at Cutlowa have been built entirely of small bricks, procured from the ruins of a large Serai which was purchased in the neighbourhood.

The above includes the whole of the works which have up to the present time been built for the purpose of Navigation, with the exception of those at the Terminus of the Cawnpoor Line which will be the subject of a separate Chapter. My Estimate of 1850 includes other works of this description which have been designed for overcoming the changes of level on the Cawnpoor and Etawah Terminal Lines; it is anticipated, however, that the smallness of these changes of level will in all probability lead to a self adjustment by a natural equalization of slope arising from the deposition of silt and sand ~~[illegible]~~ without any necessity for the introduction of separate works for navigation. The terminal

[illegible] or the Canal [illegible] with agreeably to the present plan be postponed, until the progress of the works is further advanced or until the disposition of the land supply is [illegible] understood. These works are proposed to be similar in every respect to those which are now under construction on [illegible] with the exception of those parts of the design which are expressly adapted to that particular locality. The [illegible] will be restricted to a series of [illegible] the [illegible] plan, the total amount of [illegible] to the [illegible] works being equally distributed [illegible] of an uniform [illegible] [illegible]. These works will [illegible] plan [illegible] accompanied by the necessary buildings and [illegible] [illegible] as well as a [illegible]

The [illegible] of the Branches are, it will be understood [illegible] towing paths for the [illegible] [illegible] these [illegible] and of the Canal [illegible] by [illegible] [illegible] by passages [illegible] towing paths [illegible] under the bridge [illegible]. In the former case the boats proceed in their progress without [illegible] from the [illegible] in the latter the separation of the towing rope from the [illegible] on arrival at a Bridge [illegible] indispensable. [illegible] of progress [illegible]

Diagram CXXV

~~[illegible] at the end of this chapter~~, where it will be seen that one of the river banks is connected with the [illegible] channel above bridge, and is provided [illegible] with a [illegible] attached, the river [illegible] below bridge. On the arrival of boats at the buoy, they are attached ~~[illegible]~~ to it, whilst the cattle and towing apparatus pass onwards through the passage; the boats [illegible] then either pull themselves onwards by means of the [illegible] attached to the buoy, and thus bring the boats to the towing path, or should the boats be too heavy for this purpose, the towing rope is thrown to them from above bridge, belayed, and the towing continues without the aid of the buoy chain. Facilities are thus given to the passage of boats both up and down along the whole of the channels connected with the Ganges Canal works.

It is hardly necessary to remark on the value that will be derived to the inland country generally from the means of water carriage provided by the Ganges Canal and its branches. Admitting that as a work specifically for irrigation the canal will be limited during drought to a small quantity at its lower terminations, and to occasional interruptions elsewhere, it will place the central districts and the numerous towns and villages which are on its course in immediate connection with mountain and hill produce, it will introduce new phases of commerce in the [illegible]

country through which it runs, and provide a supply of material for building purposes which at present is unknown.* Timber of all descriptions, rope, string, firewood, charcoal and the numerous articles of mountainy produce which are now from the cost of land carriage shut out from the country markets, will by means of this inland navigation be freely circulated. The above are some of the first, simplest and most readily to be accomplished benefits that the canal will confer upon the country in its subordinate character of a navigable one, but we may look forward to the [illegible] advantages bestowed upon countries [illegible] by the introduction of water carriage. The transmission of heavy goods; the circulation of country produce [illegible] the means of a cheap conveyance to the towns [illegible] are the necessary consequences of works of this nature.

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Chap v. Part iii

[The total amount of masonry and the cost per 100 cubic feet of the different works attached to the canal as a navigation, but head works are shown in the following table. The works at [illegible] and Pultee being omitted, as their cost is included in that of the supply passages under which head it will be found.

---

* In the central districts of Mynpoorie and Etawah the stalk of the castor oil plant is substituted for bamboos and rafters in the village house [illegible] —

Name of Work	Total Cubic content	[illegible]	[illegible]	Total Cost
Bahadoorabad No. 2	83346	17 9 7	Included in masonry rate	15807 3 2
Do. 3	81065	16 10 11	do.	14701 5 2
Affzulnuggur	not complete	17 2 5	not complete	not complete
Mahomedpoor	127044	13 1 0	Included in masonry rate	23960 14 9
Bedra	126675	12 12 0	3 15 9	18109 14 10
Jaoli	131507	14 13 6	Included in masonry rate	21927 1 8
Chitowra	141537	11 6 9	3 13 9	18153 11 8
Tilawna	not complete	11 6 6	not complete	not complete
Khola	147444	14 12 10	Included in masonry rate	24174 13 2
Jasnoli	not complete	12 5 6	not complete	not complete
Pulna	100420	10	2 7 7	12904 9 2
Jaura	105143	10	2 7 5	13594 15 0

The Total Cost shown above is exclusive of [illegible] of Regulating apparatus —
The Bahadoorabad Locks have [illegible] to [illegible]

Diag. CXXV

CHAPTER, VI.

Works of Distribution

Section I. Rajbaha Channels and Earthwork

II. Rajbaha heads and Masonry work

The design of the distribution works, has been so fully entered into, in Part II Chapter IV, that I need say nothing further here, than that my effort has been to avoid as far as possible any hasty proceedings in laying out these lines until the Engineers would by being relieved of the heavy works on the main canal, turn their attention undividedly to the subject. I was moreover well aware that my Successor whose attention has been directed to Irrigation, and to the best methods adopted in Europe for distributing water for that purpose, should not be hindered or entangled with any permanent works that might interrupt his progress: it is with this view that although I have constructed all the Heads for Irrigation as connected with the main Channel of the Canal, I have made them of such a form and of such a capacity of Channel that they can at any time be fitted to the requirements of modules or machinery for regulating the supply of water. It would be a mere repetition were I to describe the position and detail of these works in a tabular

-count has been given of them in the Chapter above alluded to.—

I have in the above Chapter entered fully into my views as to the general system of the dispo-sition of leading and feeder Chan-nels, and have shewn how com-pletely the tract of Country which we are called upon to irrigate is commanded by the Reservoirs of supply.

With the exception of the Masonry Heads, the greater part of which had been completed nothing further has been done in the Exca-vation of Rajbuha Channels, excepting the laying out and excavation of a portion of the main lines on the right and left of the Canal from the head of the [illegible] [illegible]; these works commenced early in the rains of 1853, and were in progress at the period of my assigning charge of the works in April 1854. On the right side 40 miles of Channel had been completed, on the left 36 miles. Material in considerable quantities had been collected and the Engineers were only waiting for a relief from the heavy works that were in progress on the main line to carry out the Rajbuhas with vigor. For this purpose a good deal of surveying and examination of ground was in progress in the Meerut and Boolundshuhur Districts under the supervision of Mr. [illegible] in preparation for extending the main lines in prolongation of Mr. [illegible] Channels which are now in progress in the Saharunpoor, Muzuffurnuggur

&c.

and the upper part of the Meerut Districts

On the 1st Section, therefore, a mere commencement has been made, in the leading Channels from the head of the Irrigation on the high land of the Doab downwards. — The work has been entirely done by Contractors, who excavate the Channel, and complete the Embankments at a rate of Rs1.4.0 per 1000 cubic feet. On the 2nd Section, which includes the masonry heads, bridges, Aqueducts, Drafts &c., the heads only have been completed to an extent corresponding with the progress of the masonry works on the main trunk and the Terminal lines from Nanoon. This, however, includes the whole of the heads as far down as Nanoon, as well as those on the Cawnpore Terminal Line; those on the Etawah Terminal are finished or in progress as far down as the 110th mile of the course of the Channel. —

None of the other works are commenced upon beyond the collection of materials, and laying out the bridge and Aqueduct on the Khutowli Drafts. —

It will be understood from what has been said before, that the whole of the cost of the works connected with this Chapter appertains to the [illegible]. They are in all respects Private undertakings, carefully laid out, and looked after by the Canal authorities, but no further chargeable to the Government than in the ad-

-vances of money made for their construction. For further information, however, on this and all other points regarding works for irrigation, I must refer to Part II Chapter IV.

Ashe

CHAPTER. VII.

Works for Machinery

The Heads under which this Chapter may be divided are:

Section I. Workshops and Machinery attached.

II. Mills for corn grinding.

Section I. Workshops and Machinery attached.

Establishments of Workshops for purposes were necessarily, under all considerations, in connexion with the Ganges Canal works, and buildings for the accommodation of Smiths and Carpenters were amongst the first to which the attention of Officers was directed. The site of the Dam and Regulating Bridge where the Canal Channel leaves the bed of the Ganges River is on the Estate of Mayapoor, on which there is neither village nor population, the land being cultivated by the people of Kunkhul, a town of considerable importance in the neighbourhood. Close by the alignment of the Canal right boundary, a Serai or Enclosure built partly of brick and partly of cut sandstone with a pucka well near it, and at some distance an unfinished Mundul or Hindoo building, were the only marks of habitable settlement; the former was used for cattle, the latter was

deserted

deserted. The Serai which in its internal measurement is 130, … × 98·5 … was readily made over by the Proprietors on an annual rent of 50 Rupees and it was immediately converted into a Work-shop. Its interior was conveniently adapted to the purpose, on two sides were covered rooms with verandahs in front extending over the full width of the Quadrangle, on the other two were Gateways, that on the [illegible] sufficient for the [illegible] of men and Cattle and having some pretensions to architectural character, the other being 11 feet in width and capable of admitting Carts. With the additions of rooms, forges &c. which were arranged [illegible] banks of the [illegible] this [illegible] was [illegible] to a greater use, and ~~[illegible]~~ while the head Quarters of the station remained at Myapore was the leading Work-shop of the Canal. [illegible] it has been used as a Work-shop room and it may be considered as an [illegible] appendage to the [illegible] in the neighbourhood.

As [illegible] as 1843 and shortly after the Roorkee Division of the Works had been established by Captain [illegible] of the Engineers, the preparation of Workshops on a more extended scale in the neighbourhood of the Solani River, and near the site of the Aqueduct was undertaken. The Town of Roorkee ~~[illegible]~~ situated on the edge of the high land [illegible] [illegible] the [illegible] [illegible] [illegible] through which the Canal passes was the

found

point on which the Aqueduct was directed; its neighbourhood was marked by undulating ground with knolls, many of which bore the marks of having been the sites of ancient villages: these were separated by ravines & hollows acting as drains or watercourses from the higher to the lower levels. The spot which I selected for the [illegible] works [illegible] was on the highest of the knolls above des-cribed, and lying immediately on the left of the Canal on its reaching the [illegible] on high land of the Doab. From the quantities of broken pots and [illegible] with which the surface was covered this spot had been evidently the site of a former village at some distance from it were the remains of Mussulman tombs. It was well adapted to our purposes, and with [illegible] uneven and irregular surface was capable of giving accommo-dation to an enclosure of [illegible] feet square. This enclosure was completed previously to my proceeding to England in 1855. [illegible] the [illegible] the Head [illegible] was provided [illegible] with accommodation for [illegible] and carpenters [illegible] [illegible] on the East & West sides. [illegible] others of different descriptions including an "Instrument" and "Model" Room was constructed on plans which accompanied my printed report of 1855. This [illegible] and

the

the accommodation [illegible]
during its time, and became the
nucleus of future buildings to
meet the constantly increasing
wants of the works. ~~[illegible]~~ During my
absence from India from 1845 to 1848 also the
whole of the Quadrangle was
received a further increase to its
accommodation by the addition
of the [illegible] rooms on the North
and South similar to those which
had been before built on the East
and West sides ~~[illegible]~~
~~had been built on the Quadrangle~~
~~[illegible]~~ It was now clear a few months
later [illegible] that the accom-
modation was entirely insuffi-
cient. At this period, moreover,
the embankment of the Aqueduct
had reached that point, where
[illegible] terminal was built later
[illegible] required for
the [illegible] embankments
forming the line of Aqueduct was
[illegible] to be brought from the sides
of the valley, and from a distance
which rendered railroads and
the wagons indispensable for
these purposes it became neces-
sary to extend the workshop
accommodation, and at the same
time to improve our means by
the application of machinery
and by the [illegible] transferred tools
[illegible] for additional work
[illegible]
[illegible] at the same
time [illegible] an application to
the [illegible] Directors [illegible] despatched
to England [illegible]

to

our particular requirements I had when in England secured the services of a practical Engineer who joined me in the month of August 1858, and about the time when the alterations which I have above alluded to were about to be commenced. Shortly before, in the month of July 1858 Lieutenant Augustus Allen an Officer in the 55th Regiment of Native Infantry was appointed as an Assistant to the Executive Engineer of the Northern Division, for the special purpose of taking charge of the works of, the designation under which he was appointed being "Engineer at the Timber yard". The [illegible] at this time [illegible] a more defined shape than they had been previously, and a system of order and method, which proved beneficial in [illegible] the manufacture of [illegible] and in carrying on the labour of the Timber yard, began to exhibit themselves in a [illegible] the [illegible]. No real step, however, could be made whilst the machinery had arrived from England, and until the increased accommodation which this as well as the increase of work rendered necessary had been completed. The improvements and additions [illegible] were at this time made, consisting in separating the [illegible] from the Timber Department, [illegible] the [illegible] the [illegible] Land [illegible], [illegible] Engine [illegible] the purpose of the [illegible] fi.

in plate LIX of the Atlas, plans of these shops are given in the fullest detail.) This new enclosure which is a mere extension of the former one extends as far south as the high road approach to the Orange Market; it occupies ground which previously had been a great disfigurement from its irregularity of surface. The filling in of the extensive hollows at [illegible] upon this irregularity, [illegible] of a [illegible] the whole of the ground on the east [illegible] of the Quadrangle and [illegible] the [illegible], and the construction of the enclosure [illegible] to give a space to the workshops, was one of the greatest possible improvements to a site which must otherwise have been not only ugly, but [illegible] from the usual causes [illegible] the [illegible] of Nature [illegible] ~~[illegible]~~ [illegible] of this [illegible] ~~[illegible]~~. This Enclosure which is comprised in its [illegible] [illegible] to [illegible] too is, [illegible] like that of the Quadrangle may be described of an open central area, surrounded by shops and warehouses resting upon the [illegible] wall; the shops are arranged in open lines for the use of the Carpenters; the [illegible] of the [illegible] [illegible] the being fitted with doors and means for the protection of property.

It will be understood from the position of the Quadrangle [illegible], situated as it is on a high ground, that

it is much elevated above the
Canal which passes close by and
parallel to it, a sufficient distance
having been left between them
to admit of an extension to
the buildings on that face. Upon
the rise on the western side of
the old enclosure of 1843, very ex-
tensive accommodation, in the
shape of lathe rooms &c has
been built — the higher portion
of the ground on that on a level
with the existing buildings being
occupied by Cranes, Lathes and
Machinery, that on the lower
which constitutes a basement
with an upper story being devoted
to furnaces and boilers with the
Engines, Machinery, the upper
story, which lies on the same level
with the lathe rooms being oc-
cupied by the [illegible]
and [illegible]. The façade
formed by the above mass of
buildings is a prolongation of
the western wall of the [illegible]
yard enclosure and at a distance
of 40 feet from the steps or Ghats
which line the Aqueduct. Here it
was intended to establish wharfs
and Cranes in communication
with the workshops again — On
the Eastern face of the Store
Quadrangle, and directly
opposite to the buildings above
described, the Model Department
which as originally built consis-
ted of one room of 40 × 20, has
been increased by the addition
of a room of equal dimensions
placed parallel to & connected with
it by a wide aperture supported
on

on each side by plain Doric pilasters, isolated and flanking circular headed niches formed in the walls. This large room is furnished with Tables made of [illegible] Slate, and is devoted wholly to the [illegible], [illegible] which occupies [illegible] placed in convenient positions in the room, and to pictures of either [illegible] works of great interest, or of men who have distinguished themselves in connection with them. This addition to the Old Council room had a projection equal in extent to the [illegible] of the new building, [illegible] the [illegible]; this projection was [illegible] by a [illegible] in character with that of the original work; the centre was occupied by a [illegible], the basement [illegible] a broad stairway which acts as an entrance hall or vestibule to the Council room.

The [illegible] towers extended through [illegible] years so that additions and improvements adapted to circumstances were constantly in progress; in [illegible], however, the most necessary portion including the [illegible] and [illegible] accommodation was entirely completed, and in 1851 the [illegible] which had been [illegible] to the Court of [illegible]. It consisted of the following:

1. 10 HP condensing Steam Engine with Boiler.

1

1 Large planing machine
1 Drilling and boring Do
1 Small Drilling Do
1 Punching and Shearing Do
1 Lathe 12 feet
1 Screw cutting Lathe 8 feet
1 Do Do 7 "
1 Steam [illegible]
1 Screwing machine
1 Blowing Fan
2 Grind Stones

Saw machinery

1 [illegible] Frame
1 Deal Do
1 3' Circular Saw
1 2' Do

The time was lost by Lieut. Allen and by [illegible] the Practical Engineer in fixing the machinery and not [illegible] [illegible] March 1852. [illegible] [illegible] for the [illegible] that took place in [illegible] [illegible]. From some mistake in [illegible], the Steam Engine which was sent out was one adapted to be placed on the opposite side to what the buildings for them had been designed, it was therefore necessary to change the direction of the steam pipe, the work for which could be done at no place nearer than Calcutta. This was a great loss of time although it was [illegible] in a great measure by completing in the interim the different arrangements in the machinery room. The delay [illegible] the Saw machinery [illegible] most [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] unaccountable [illegible], was [illegible]

demand and a single and dual shaft was substituted. ~~[illegible]~~ A number of minor objections ~~[illegible]~~ were raised ~~to parts of the machine~~ all of which had to be corrected and ~~portions of the machinery itself~~ [illegible] from their weakness had to be strengthened whereby time was necessarily occupied ~~time~~. ~~[illegible]~~ The Steam Engine ~~[illegible]~~, was a very small one, and the machinery although not of the best being as the Practical Engineer remarked "made in Europe taken to the "colonies" has been [illegible] but [illegible] [illegible].

The addition to the machinery [illegible] introduced by Mr Murdoch the Practical Engineer ~~[illegible]~~ did up [illegible] ½ horse power Engine which I had many years before purchased ~~[illegible]~~. This ~~[illegible]~~ with a new boiler (that I had brought from England for the purpose) was up to the [illegible] of the large Engine [illegible] and very usefully employed in turning Lathes a grind stone and a fountain [illegible] water [illegible] the [illegible] of the [illegible] all [illegible]. ~~[illegible]~~ Being [illegible] and in all probability [illegible] this Engine was [illegible] complicated in all parts it was [illegible] and [illegible] [illegible] after [illegible] [illegible] laid aside.

The Lathes which were turned by the little Engine were brought out by me [illegible] Rolleyfield from which the following articles were received at Roorkee, almost simultaneously with the arrival of Mr Murdoch the practical Engineer, under whom they had been selected.

1. Self acting Lathe [illegible] 8 inch Centre, for turning wrought iron.

1. 6 inch [illegible] Lathe (both lathes being complete in all respects for every kind of work.)

Tools of various descriptions.

Besides the above the following [illegible] had been purchased for the use of the Works

1. 5 inch Foot Lathe [illegible]

1. 5 inch do. [illegible] Screw cutting by Whitworth

1. 5 inch do. do.

1. 5 inch Self acting foot lathe by Whitworth

1. small 5 inch foot lathe with common T rest

1. 7 inch Lathe

so that on the arrival of the greater batch of machinery from the Court of Directors the shops were very fairly supplied with the means for carrying on any work that they were likely to be called upon to perform.—

During the whole of this period [illegible] and from the date of [illegible] during the works [illegible] all [illegible] most [illegible] directed [illegible] the manufacture of Tools, with [illegible]

since previously the shops had been totally unprovided, he had also prepared a variety of useful machines for simplifying work among which I may enumerate the following:—

Steam hammer
Superior Bolt screwing tools for hand and machine screwing.
Punching machine
Drilling do
Nut grooving do
Pumping engine for supplying the premises with water
Moulding tools ~~among [illegible] with [illegible] and [illegible] [illegible] found in the [illegible] Workshops~~

He had also introduced amongst the native workmen a variety of improvements, not amongst the least important being the general use of the improved use of the file, and the substitution of [illegible]. A great deal in use of practical improvements had also been introduced into the system of working iron, and with economy of fuel. The fuel used is entirely charcoal, and the forges previously to the introduction of the American apparatus, were worked by large [illegible] and hand [illegible], [illegible] the native forges [illegible] fixed, where the [illegible] by leather bags to which a nozzle is applied. These forges were [illegible] [illegible] added and without pulling down the building in which

when they were placed, they were by a judicious disposition brought in direct contact with the blast from the blowing machine, the adaptation of which to the steam engine was chiefly improved by Lieut. Allen, who as in the case of the Saw Machinery, changed a complication of shafts into a simple bearing on the main axle. This new arrangement of the forges gave additional room for working, improved the ventilation of the two arcaded rooms in which they are situated, and greatly economized space. The whole of the improvements that were made in connection with the fitting up of the machinery, and with the reorganization of the natural dependencies upon it, appeared to me to be very satisfactory.

During the above period, ~~that~~, a brass foundry on a small scale had been established, a weighing apparatus similar to that which is so frequently used at Turnpikes when the value of the load is read off in a side room, had been attached to the floor of the main gateway through which loaded carts enter. A Department of painters for the purpose of graduating levelling rods &c. had been organized and Saddle and Harness makers carried on a very successful trade in making harness of all descriptions, shoulder straps for the ammunition, together with the whole of the Leather work required in the establishment board of

term

[illegible]...

The Shops up to the year 1851 were employed entirely on the manufacture of Articles required for the Ganges Canal Works, which kept them fully occupied, boats both of wood and Iron had been made for the use of a navigable Canal which since 1848 had been in constant use for the purpose of transporting boulders & building material from Myapoor and the branch on the Ganges in its vicinity, to the Myapoor and Bahadrabad works; numbers of Earth wagons had been made for the use of the Solani aqueduct Embankments, and for the supply of material from the Brick manufactories in the neighbourhood; [illegible], [illegible] rails, and other tools necessary for keeping up this system of communication had been in constant progress. The works at Roorkee had also been supplied with both wagons and rails; and the numberless articles more especially in demand for sluices of Dams, Regulating bridges, and for all the numerous works other works in progress were carried on without interruption.

Early in 1851 the demand for both surveying and mathematical Instruments at the Roorkee Engineering College raised a question whether it was not advisable to [illegible] advantage [illegible] in connection with a Department for the manufacture and repair of the [illegible] required in the North West Provinces, and

and the demand that these works occasioned for Instruments of all descriptions appeared to point out the Roorkee College as an Institution in which a Depot of Instruments might be well maintained for the purpose of distribution. Roorkee with its Civil Engineers College, Workshops, model Department, and in the immediate neighbourhood of the most interesting portion of the Ganges Canal Works, appeared to be in many ways more appropriate for the purpose of the Depot, than the different Ordnance magazines scattered over the Country, whilst for repairs, it was beyond all question more convenient than Calcutta.

It was proposed, therefore, that the mathematical and scientific Instruments now dispersed in the different magazines should be collected into a well regulated depot at Roorkee, that a stock of the best Instruments of all kinds commonly required, be maintained by regular supplies from England, and that these should be held for sale, or for loan on the public service under rules drawn up for the purpose and promulgated for general information.

It was further proposed that there should be a Workshop in connection with the Depot for the repair of Instruments procured from England and for the manufacture of such as can be made in this country.—

The Plan was extended

by the following strong recommen-dation. 1st [illegible] that [illegible] of such instruments of the North West Provinces and the Punjab. 2nd the insufficient provision for their safe-keeping [illegible] several [illegible] and workshops and [illegible] [illegible] than [illegible] [illegible] to Calcutta, and it was approved of with no dissentient voice.

It was observed with regard to the establishment of this Depot at Agra as the Head Quarter Station of the North Western Provinces instead of at Roorkee, that the latter is in the immediate [illegible] of the great works of irrigation and con-struction on the Ganges Canal, and that were [illegible] not yet finished, and as would [illegible] [illegible] they will be in [illegible] the most [illegible] [illegible] of any [illegible] in India that [illegible] with [illegible] [illegible] are there assisted with skilled artizans with seasoned materials and power [illegible] of working up these materials; that moreover at Roorkee there is a large and in-creasing Collegiate Establishment, the students of which it is of much importance to render familiar with everything that concerns the instruments with which they will have to work. Agra, although the metropolis of the North West Pro-vinces and the seat of the Civil Government has none of these advan-tages, it does not even contain a Superintending Engineer or any Scientific Officer excepting the Executive Engineer of the Division.

Roorkee.

[illegible] it was maintained had on the contrary the greatest facilities for carrying out the project. Lieut A. A[illegible] of the 55th N. I. in charge of the workshops was peculiarly skilful in making and repairing instruments and in training operatives to execute such work. Lieut [illegible] had already done much in this way and his presence at Roor[kee] [illegible] obviated the necessity of [illegible] the [illegible] [illegible] at the expense of bringing out from England a [illegible] skilled instrument maker. [illegible] had been done even at this time in [illegible] [illegible] regarding the progress of the manufacture of cheap [illegible] substitutes [illegible] such of the more expensive instruments as could be made up easily in this country [illegible] within the means of native workmen. It was clearly desirable that the efforts which had been thus irregularly and desultorily put forth should be reduced to order and systematically worked.

The delay & annoyance that had been experienced in the adjustment of the Steam Engine in consequence of our inability to obtain a casting so as to direct the steam [illegible] upon the [illegible] and to [illegible] the defect of the machinery as received from the [illegible] brought prominently [illegible] the necessity that existed [illegible] [illegible] an Iron-foundry [illegible] to the workshops. The case alluded to is worthy of recording as an example of how a blundering mistake in the 1st instance

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men about the screws who do
acquaint[illegible] [illegible] [illegible] off
[illegible] the means of remedying
it. In the present case the Steam
Pipe which ought to have had its
bearing upon the boilers which
were placed on the left of the Steam
Engine, had it on the right, so
that without an alteration of the
direction of the pipe on its leaving
the cylinder, the machine was
useless, unless the building had
been remodelled to adapt itself
to the Engine. All that was re-
quired was a short bit of pipe
with a bend without in it,
which had a Foundry been pre-
sent we might have made in
a few days. Now, on the contrary,
although no time was lost in
writing and sending drawings
to Calcutta we did not receive
the article required until a period
of 4 months had passed. We had
in fact to send to a distance of
1000 miles to get a thing that might
with ease have been made at
Roorkee had a Foundry been in
existence. This although the first and
leading inconvenience was only
one out of a great many which
gradually shewed themselves as
the works progressed. In a
letter which at this period I ad-
dressed to the Military Board it
[illegible] drawing attention
to the above circumstances "I am
by no means undervaluing the
[illegible] of our existing works
in suggesting that no time should
be lost in establishing an Iron
Foundry at Roorkee we require the
services of a man who is acquainted than an

with the act but beyond this and the construction of the necessary buildings, I do not imagine that the addition of the Foundry to the Yard would lead to any extraordinary expense whilst it would give us the means of supplying ourselves at once with articles which we now at a great cost of time and carriage have to procure either from England or Calcutta, and in a late instance instead of being able at once to supply ourselves with a portion of Steam pipe we have been forced to send a commission for its manufacture to a Foundry situated at a distance of 1000 miles from Roorkee. With reference however to the higher advantages and to the more general application of these workshops to the supply of the Provinces with Iron work in other forms as cast, it strikes me that the sooner ~~[illegible]~~ the Foundry arrangements are entered upon the better, the whole of these provinces might in my opinion, and ought to be supplied with Iron bridges, Roofs, Castings, &c from Roorkee and whilst Calcutta is the central point for the Lower Provinces and Bengal proper, Roorkee would be more centrically, as well as more conveniently situated for the Provinces to the North. In conclusion I may observe that even with reference to the cost of English Iron as far North as Delhi and the fact that we can at present procure that material at Roorkee at a cheaper rate than we can obtain Iron from Gwalior, I am by no means satisfied that in the extensive

[illegible]

distribution of Iron Mines throughout the mountains in immediate approximation to Roorkee, we may not through a well appointed agency open out an entirely new market for Iron, and turn to useful account one of the neglected ores of the Himalaya mountains".

The Establishment of workshops and Foundry at Roorkee a place which was situated within 16 miles of the Sewaliks and 40 miles of the Himalayas, would it was supposed bring into activity any dormant elements that the [illegible] of the Himalayas might have upon the attention of Metallurgists. With regard to supplying charcoal and [illegible] to supply iron, the Roorkee Foundry would be independent on its own resources; whilst the clays and earths which abound especially in the Sewalik mountains, would be a fruitful field of interest in the manufacture of pottery.

The whole of the above views was adopted by the authorities without any demurrer, and having ultimately been approved of by the Court of Directors were then ordered to be carried out as early as possible. The delay that has occurred in [illegible] acting on instructions which were asked for with such eagerness, arises from the great extent of the works both at the Canal and College, which has up to the present period, absorbed every hand as well as every labourer that could be collected together; [illegible]

this cause the extension of buildings necessary for the Foundry and other purposes has been most unwillingly placed in abeyance, at least so far that the new buildings have only been carried on as material and opportunity offered. The designs however, have been well matured, and progress although slow, has not been altogether stopped.

Correspondence on the subject of this extension of Factory Shops which commenced in July 1866 and which has ended in the approval of the Court of Directors to the whole of the measures which had been recommended, led to the following arrangements, which may be best explained in the words of a minute dated the 15th [illegible] 1867 and [illegible] by the [illegible] of the correspondence.

1. "As introductory to the following recommendations it may be better to explain the views entertained as to the Mathematical Instrument Department as connected with the General Workshops at Roorkee. I believe that these views are the same as those expressed in the Secretary Chief Engineer's letter to the Military Board No 398 A of [illegible] dated the 29th July 1856, on this subject, but as the whole of the scheme depends upon a perfect understanding of the views of the Government on this point it is as well to explain my reading of them.

2. The Civil Engineering College at Roorkee is to be the Depot for the [illegible] Mathematical Instruments, Astronomical

Geographical, Meteorological, and Mathematical. It is to be under the control of the principal of the College for the time being.

3. All Instruments the property of Government now deposited in store in the Magazines or elsewhere are to be transferred to this depôt and a supply of those in most common demand is to be maintained, not only for the use of those employed in the Public Service, who will obtain them under certain regulations to be hereafter adopted, but for the public generally, instruments being thus available for the purchase [illegible] as for the equipment of individuals on their private or privately organized for scientific purposes. The prices to be calculated at the actual cost upon the [illegible]. Barometers and other Instruments for meteorological purposes, which are now obtained with great difficulty, and for the want of which so much valuable information [illegible], will by these means be always available, at a price, moreover, so [illegible] calculated to the [illegible] and to be [illegible] as to render a utility [illegible] of these [illegible] generally available.

4. The Mathematical Department [illegible] workshops will be [illegible] the [illegible] repairing [illegible] ultimate deposit in the depôt. All instruments received [illegible] the Magazines or elsewhere [illegible]

will pass through this Department
previously to their being lodged
in the Depot. Its control will
be vested in the Superintendent
of the workshops, whose transac-
tions with the Principal of the
Civil Engineers College as the Of-
ficer in charge of the Depot
will be conducted in the usual
official form of correspondence
and record.

5. It is understood that by keep-
ing the Depot and Departments
of Manufacture and repair dis-
tinct and under the management
of Officers independent of each other,
the Instruments will undergo pro-
per scrutiny both in their [illegible]
[illegible] and adjustment, both of
which tend to insure the quan-
tity [illegible] and keeping a suppl-
y [illegible] of standard Instru-
ments ready for immediate use.

6. The Depot, therefore, being
understood to be the "Depot" and
the Workshops the school of repair
and manufacture, I now proceed
to the subject of this memorandum
viz: the Constitution of the Roorkee
Workshops.

7. The Workshops at Roorkee
would under a complete Scheme
for making them generally useful
in the North Western Provinces con-
sist of the following Departments

1st Iron & Wood for General purposes
2nd Mathematical Instruments
3. Foundry.

8. I would place the whole
under charge of one individual
called the Superintendent of the
Roorkee Workshops, whose salary
would be 500 Rupees per mensem.

with an Office Establishment. As an Executive Officer he would open an Account with the Accountant General of the [illegible] Provinces, and his duties would be carried on under the direction of the Director of the Canals, and Works and the Superintendent of Canals North. It is indispensable that the Executive Engineer in charge of the Works in the Northern Division of the Ganges Canal should have unlimited power in procuring [illegible] of these Works, [illegible] [illegible] from the Executive Engineer should be attended to in preference to all others. Should this not be admitted or not carried out to its fullest extent, the Executive Engineer must necessarily fall back upon his own resources and establish independent workshops for his own supply.

I. [illegible] Wood, for General purposes

This Department would consist of the present [illegible] Timber yards where the work on roofs and suspension bridges, the Timber work of all descriptions required in the Department of Public Works, and the usual manufacture of all articles of [illegible] and wood required in the different departments of the service would be undertaken.

II. The Iron Yard would contain [illegible] for the maintenance of a Depot of Hardware, such as Iron, Locks, Keys, Hinges, Nails and other articles used in the Department of Public Works, [illegible] [illegible] the sale of

these articles to the Public Departments of Government although these Departments as a general rule, and when there was a deficiency in Store, would have the preference. The great object that I would have in view would be to hold out to the people of the Country a supply of wares of a superior description to those made by themselves; to introduce amongst them at prices which would be remunerative, tools of a superior description; and to put them in the way of not only (by inspection of our Shops) observing the European method of working, and judging of its superiority over their own; but of possessing by purchase the means of imitating us, and advancing in a parallel course of improvement. In illustration of this object, I may mention that a large supply of handsaws, which were procured from England for the purpose above mentioned, has been disposed of, and articles of a similar description are in large demand by the native Carpenters. I would also observe, that the distribution of Stores of this description would keep up a healthy circulation in the Depot; it would prevent that accumulation of old and obsolete material, which I am given to understand exists to a great extent in the magazines of this Presidency, and which in the shape of the very articles which I allude to above did exist up to a very late period in the Warehouse of the Executive Engineer of the Tanjore

Division

Division of Public Works. In the case of the magazine stores, public sale at distant periods relieve the warehouses from lumber and refuse material, but at an enormous sacrifice to the State, whereas had the articles not required been disposed of from time to time by private sale, the objects to which I have above alluded, and on the advantage of which I place so much weight, would for a long series of years have been in steady progress

11. The Military Board in their letter to the Agra Government No 3700 of the 5th August 1851, have in pointing out that all the [illegible] now lying in the magazines might be advantageously collected at Roorkee, gone very far in approving of the Roorkee shops becoming the Central Depot of stores and supply; and it strikes me that with the exception of articles strictly appertaining to the military and [illegible] of the Ordnance Department, all those magazines lying within a reasonable distance might with advantage be sent to Roorkee, which as a Civil branch of works is connected [illegible] with education and established for the purposes of supply and distribution would turn to better account the stores now in course of receipt or in deposit, and would be better able to dispose economically of the residues, than were they sold by public auction at the periodical magazine sales.

12. The "Timber Yard" would in the same way act as a Depot

Wil[illegible]

for wood of all descriptions, especially Saul (Shorea robusta) and the proximity of Roorkee to the Sewalik Forests, as well as to the Himalayas, would extend the benefit of this yard as a wood depôt, by enabling the Superintendent to keep up a supply of many useful Hill articles especially woods which are at present little known and their value (from the difficulty of obtaining them, and in many cases from the ignorance of their existence) less appreciated. A true Box (Buxus Emarginatus) is easily procurable from the neighbourhood of Dehra Doon; it appears to be of excellent quality and is likely to be serviceable to the Wood Engraving Department of the College. Pitch, Tar and Turpentine from the Pinus Longifolia (Cheer) of the Sewaliks (during my Superintendence of the Eastern Jumna Canal a Tar manufactory was constantly at work under my direction at the [illegible] foot of the Sewalik mountains) are to be made with the greatest ease, and from local fabrication are more likely to offer a better and a cheaper supply than those supplied from the Magazines. [illegible] materials, Ropes, Bags and a variety of materials useful in both [illegible] purposes, might be brought into general circulation through the medium of the Depôt.

§13. [illegible] between the [illegible] of Roorkee on the [illegible]

would by giving the means of floating down Rafts of timber enable the Depot to be supplied with a variety of woods from the interior of the Himalayas. Deodar Ash, Walnut, and woods indigenous to the temperate climate of the Interior might by these means be collected at Roorkee, & by an economical distribution of Time and Labor also, these rafts might carry supplies of various material. And I have no doubt that at a very early period a correspondence having been established between Roorkee and distant points in the Himalayas, numerous products would come to light which at present are unknown. I might here allude to the great variety of Clays, many of which I have rendered available for Pottery and for other uses, which exist in the Siwaliks and in their neighborhood and to the advantages that we should derive from the presence of an Officer with the talents and energy of Dr Alexander Hunter of the Madras Medical Service, whose researches in the natural resources of his own Presidency, in doing honor to himself, and to all whom his example has carried with him ought to stimulate us not to be behind hand in a field, I have no hesitation in saying, of equal if not greater importance, than any in the British possessions in India. To carry this subject further would be foreign to the object of this paper but the Industrial

Exhibition and Dr. Royle's pamphlet on the proposed contributions from India will to all who are interested in rescuing the natural products of a large extent of country from their present obscurity, shew what an active agent the Roorkee workshops may become in not only doing this good work towards the Himalaya, but also to the Provinces of Upper India.—

II. Mathematical Department

15.— It having been decided that the Depot for Surveying and Mathematical Instruments should be attached to the College, and that the manufacture and repair should be a separate Department of the Roorkee Workshops, we have now to take into consideration the best means in carrying out the latter object.

16. This object has been described in the Honorable the Lieutenant Governor's minute dated the 21st May 1850 as follows.

1st The manufacture of Instruments in common use, and generally made up in this country, Levelling Staves, perambulators, Chains, plane tables, [illegible] &c. The invention and [illegible] make of cheap substitutes for expensive machinery: e.g. Common carpenters might make up plane tables, Quadrants and levelling Instruments, which would enable an ingenious man to take, with considerable approach to accuracy both horizontal and vertical angles. Water or T Levels for levelling, giving a [illegible]

or ingenuity in popularizing the materials for scientific research.

2nd The repair of Surveying and Mathematical Instruments.

"17. With reference to the 1st item, without discussing the advantages that would be derived from maintaining a depot of articles as enumerated above both by the Canal Office and the Civil Engineer; the simple fact of readily ~~[illegible]~~ supplying the one ~~[illegible]~~ with Levelling staves & the other ~~[illegible]~~ with Chains would ~~[illegible]~~ gain their ~~[illegible]~~ sympathy ~~[illegible]~~. Levelling Staves on the best plan of graduation are now made by Lieut. Allen in a manner equal to any that could be turned out of a London shop. Chains are also made equally well and both these articles have the advantage of being graduated and compared with the standard: the facility therefore for carrying out the first object of his Honor's minute, there [illegible] no doubt whatever.

"18. The difficulties in which an Officer is placed in these provinces from the want of the means of having Instruments repaired has been well pointed out by Colonel Everest in the preface to his last work on the Indian Meridional Arc. Colonel Everest has shewn moreover, what can be done by a man of skill and intelligence, when [illegible] perfectly acquainted with the construction and value of the parts, placed in the midst of a wilderness, with an Instrument out of repair [illegible] or [illegible] damaged by ~~[illegible]~~ circumstances to which

ne is perfectly available! The deductions are obvious: 1st That even the most complicated Astronomical Instrument can be repaired here without the aid of the professional Craftsman, and 2ndly that, by an Institution similar to that now proposed, these provinces, remote as they may be from either the metropolis of India or from the skill and manufactories of Europe, may find within themselves the means of not only repairing but also of making Instruments.

Plunk

"19. The making of Instruments, however, is a question upon which a few remarks may be necessary. It is not presumed that the Mathematical Department of [illegible] would during the present period or even for many years compete with Europe in the making the most complicated apparatus attached to the Astronomers Observatories, nor would it pretend even to a competition with the professed mathematical Instrument maker either in the best description of Surveying Circles or in the Instruments attached to the Drawing Department. Neither is it that even were the Workshops provided with efficient men, it would take some time before the complicated machinery necessary for the manufacture of Articles in large Quantities would enable them to compete with English prices, but to every one who is acquainted with the extraordinary patience of the native character, the

delivery [illegible] [illegible] [illegible] [illegible]
is the characteristic of our native
timbers, and the great capacity
(which I believe is not only)
for [illegible] with incalculable powers
of the highest order, will, in [illegible]
[illegible] the character to be carried,
[illegible] [illegible] [illegible] appreciating the
value of the [illegible] that the idea
[illegible] improvement, and
[illegible] [illegible] a great [illegible] [illegible]
[illegible] altogether the [illegible]
[illegible] may not only be able to
compete with Europe in the quality
but from the cheapness of native
labor, undersell them in the prices
of their instruments. I consider that
the present Engineer of the Corps
is peculiarly qualified to carry
out the models. The Lieutenant
Governor [illegible] on this point
and [illegible] [illegible] [illegible] the encourage-
ment that I would propose [illegible]
[illegible] [illegible] advance [illegible]
[illegible] [illegible], will in all
[illegible] [illegible] be certain.
[illegible] the first articles
which would be necessary, for the
purpose of instrument making
[illegible] [illegible], which must
be procured from England; but
should there be any difficulty here
[illegible] [illegible] [illegible], and [illegible]
[illegible] [illegible] [illegible] than that
[illegible] [illegible] is required to
make [illegible] independent by
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible], but I [illegible]
[illegible] [illegible] [illegible] that I shall
not be [illegible]. I [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]!
[illegible]

10000 a 12000 Rupees.

Additional and separate accommodation will be required for this Department, although such arrangements are proposed to be made, as well as the compactness and that the shops which are specifically for mathematical instrument purposes, in immediate connection with the general shops.

Lieutenant Allen with whom I have consulted, and who is conversant with the contents of this memorandum, considers that two main rooms of the following proportions are indispensable.

1st Finishing room for instruments 70 x 20

2 Carpenters & Blacksmiths workshop 100 x 20

these with small rooms attached may be easily gained by additions and alterations to the immediately available [illegible] of the [illegible] in the existing buildings. They must be upper storied rooms and this may probably lead to very great [illegible] in the necessary modifications for adapting the present arrangement to a superstructure for which they were not intended. I don't think that the cost can be estimated at any at less than 5000 Rupees, it may however be less; Lieut Allen considers that 3000 Rupees will cover the whole.

I would endeavor to make it understood, that the means at our disposal in the general workshops described as Gun and Carriage yards, will be available for the mathematical as well as for the Foundry Departments, the whole being under one institution and controlled by one head. The mathe-

matical

matical instrument shops however will require certain specific appointments and the following articles may in a general way be considered indispensable

2 Screwcutting mandrel Lathes, say £	60 ..
Set of apparatus similar to those used by Mess^rs Troughton & Simms	50 ..
Grinding and polishing apparatus, Polishing press	45 ..
Small tools, bench vices, drills &c &c	75 ..
Small stores. Materials and parts of instruments ready made with a view to more immediate repairs, particularly of instruments to be received from the magazines, viz^t Object glasses, brass tubes, steel and brass wire, sheet brass &c &c	80 ..
Total £	310 ..
Cost of carriage &c	80 ..
Grand total £	390 ..

or say that a sum of about 4000 rupees will be required for original outlay in these articles.

Lieut. Allen considers that in this most important question of establishment of Artificers, very few trained natives possessing the requisite skill might at this moment be obtained from the local shops, and that an equal number might be collected from the Provinces who after a little instruction would be fully capable of working in the mathematical instrument Department, but the training of an efficient establishment will require time, and the amount of work undertaken must be proportioned to the growth of the establishment.

Lieut. Allen, however, suggests that the following scale of establishment, as one that may be adequate when fully trained for the performance of the work required

for

for the first few years.--

Smiths	1 Mistry @ 30/ p.m.	30		
	2 Smiths @ 20/ ..	40		
	4 do @ 15/ ..	60		
	6 do @ 12/ ..	72		
	6 do @ 8/ ..	48		
	12 do @ 6/ ..	72		
	5 do @ 4/ ..	20	342	
Carpenters	1 Carpenter @ 16/	16		
	6 do @ 12/	72		
	4 do @ 8/	32	120	
Total Company's Rupees p. month			462	

Both as regards amount of salary and number of individuals employed, the appointment of the above people would be progressive. Remarkable instances of ability and talent ought, however, to be rewarded and deserve at a higher amount than is noted in the above scale, and I would give in to encourage such by increase of salary to those who obtain from the Engineer of the Corps a certificate of the highest qualifications. I would recommend, to those of this description, besides a periodical increase of salary, say at the termination of every five years of service, a certain table of salary that might be determined on. It is the utter want of prospect in the present system that prevents us from obtaining the services of educated men, who on the first opening in another Department leave us to better themselves.--

As above observed the mathematical Department would lead to the following expense.--

Say. Buildings	5000	
Tools	4000	
Dividing apparatus	11000	
Total Company's Rupees	20000	

with a monthly Establishment amounting

amounting to Co's Rs 40[illegible].0.0.– 1180

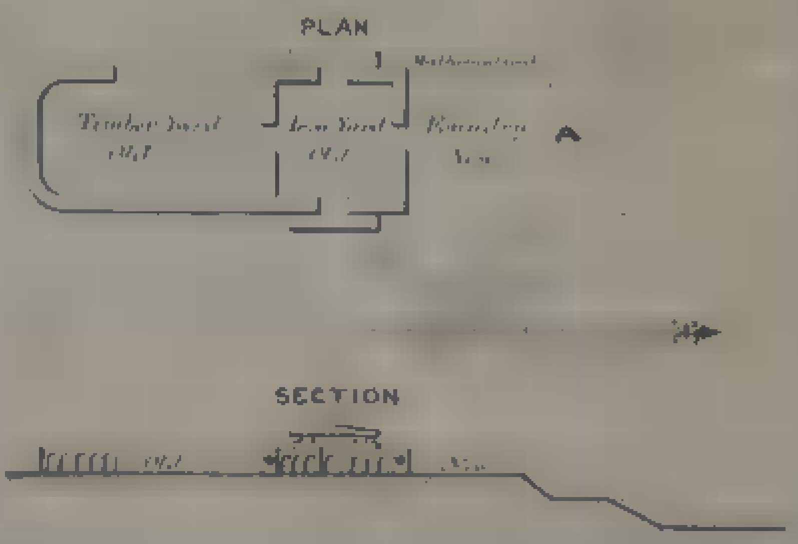
III. Foundry.–

I have in the list of Establishment included that which may be required for this branch of the workshops, but as I consider that the economical value of a Department of this sort depends entirely on the adoption of both the metal and fuel which are available in the neighborhood and not in the importation of European products whether Iron or Coke, I would commence operations on a limited scale. I would recommend that the planning and laying out of the workshops should be designed on an unlimited establishment in a foundry, and in the meantime I would prosecute all enquiries as to the nature of the Iron to be procured from the Himalayas, and from the mines to the westward of India, as to its cost on delivery at Roorkee and as to its comparative merits both practically and commercially with the Iron in use elsewhere. I have begun to collect specimens of the different Iron ores and metals of the Himalaya districts, and in connection with the Museum of Economic Geology at Roorkee to form a valuable ground work for analysis and experiment. A great deal may be done by degrees in carrying out this examination and practical experiments may be made in the use of Charcoal as fuel for the purposes of a Foundry

in

In smelting Iron, charcoal is extensively used in different parts of India, and up to the middle of the last Century was very generally used in England. Its value for casting rests more on its economical results than in its insufficiency for the purpose. I have in a Diagram below shewn the position that a Foundry would hold on the limits of premises; it would constitute a completion of the [illegible] buildings as connected with the Mathematical and those for other purposes on the northern face of the present enclosure.

Diag. CXXVI



The dotted lines shew the positions of the Foundry with the Mathematical Instrument buildings on the west: and others for general purposes on the north, covering the steep descent of the ground as shewn in the Section. I would occupy the line at A with quarters or rooms for the accommodation of the Practical Engineers and Europeans attached to the workshops, the presence of whom near at hand experience has shewn to me to be of the greatest value. The [illegible] [illegible] gained by the practice

Natives

[illegible] the [illegible] would [illegible] the [illegible] accommodation to be [illegible] very satisfactory. The [illegible] were [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] equational [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at [illegible] 1000 [illegible] pounds.

(353, A vol 2 p iii cm) [illegible]

[illegible] [illegible] a table [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the [illegible] [illegible] [illegible]

[illegible]		[illegible]
[illegible]	500	
[illegible]	300	800
[illegible]		
[illegible] 150 [illegible]	200	
[illegible]	150	
[illegible]	50	
[illegible]	21	
[illegible]	4	450
[illegible]		
[illegible]	50	
[illegible]	40	
[illegible]	[illegible]	
[illegible]	15	
[illegible]	10	[illegible]
[illegible]		
[illegible]		
[illegible]	250	
2 [illegible]	200	
3 [illegible]	100	
[illegible]	50	
[illegible]	30	
[illegible]	16	
[illegible]	12	
[illegible]	40	
[illegible] 15 [illegible]	60	
[illegible] 15 [illegible]	66	
[illegible] 15 [illegible]	80	
[illegible]	100	
[illegible]	210	
[illegible]	180	
20 [illegible]	80	1400
[illegible]		
[illegible]	90	
[illegible]	70	
[illegible]	25	
[illegible]	16	
3 [illegible]	14	
[illegible]	12	
[illegible]	72	
15 [illegible] 10 [illegible]	150	
[illegible]	150	
[illegible] 8 [illegible]	160	
[illegible]	140	
20 [illegible]	80	1004
[illegible]		
1 [illegible]		
1 [illegible]		
1 [illegible]		
[illegible]		
[illegible]		
6 [illegible]		

[illegible]

[illegible] [illegible] includes [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

in the Mathematical Department should be added the Mathematical Department Establishment in the Arsenal [illegible] for the [illegible], as the employment of the work is of one nature. [illegible] detail of the Establishment of the Mathematical Department was given before.

IV. [illegible]

<u>Appointments.</u> [illegible] Deputy [illegible] in order and [illegible] would [illegible] make them [illegible] distributed [illegible] very [illegible] appointments, but [illegible] would be [illegible] [illegible] Deputy [illegible] would [illegible] the whole, but the Deputy [illegible] would [illegible] that [illegible] the Mathematical Department.

The salaries recommended would be

Superintendent 500 rupees per month + 100 [illegible]

Deputy [illegible] 300 rupees per month

The maximum allowance of the Superintendent is intended to [illegible] charges [illegible] [illegible] the [illegible]

that

that branch to which his attention [illegible] be frequently directed.

Where Uncovenanted Servants (Professional men) are employed their salaries might be left for adjustment at the period of appointment.

English and Native Officer | It will be understood from what has been [said] before, that the constitution of these Shops will entail upon the Superintendent the charge of not only an immense quantity but of a most varied description of [illegible] [illegible] [illegible] the requirements of which [illegible] [illegible] will rest with the Superintendent. It is important, therefore, to prevent disappointment [illegible], and to relieve the Superintendent [illegible] [illegible] [illegible] [illegible] [illegible] Officer [illegible] [illegible] Book Keeper. The necessity of having a man of [illegible] ~~[illegible]~~ is [illegible], [illegible] appointment is [illegible] [illegible] [illegible] [illegible] [illegible] to relieve the Superintendent [illegible] from the [illegible] of detail [illegible] [illegible] [illegible] in the [illegible] [illegible] [illegible] [illegible] the same [illegible] [illegible] [illegible] [illegible] Executive Engineering duties, [illegible] [illegible] [illegible] [illegible] the Department of Public Works [illegible] [illegible] [illegible] the [illegible] of [illegible] [illegible] the duties [illegible] Accountants. To obtain the [illegible] of a man of this description it might be necessary to offer a [illegible] salary than is now [illegible] to Accountants [illegible] [illegible] and [illegible] [illegible] [illegible] should [illegible] out to [illegible] a practical [illegible] [illegible]. [illegible] might

might commence at Rs 150 or Rs 200 per month according to the qualifications of the candidate, with an increase of 10 Rupees a month at the end of every 5 years of tried and good service. Increase to be authorized by the Government on Certificate from the Superintendent of the Ships. The Assistant Book keeper or Accountant would naturally look to the higher appointment for promotion. —

"The 2 English writers would consist of

1 for the Iron and Timber Yard

1 for the Mathematical Department

The Native Office does not I imagine require any explanation. The Head Native Assistant would look to all the native accounts and proceedings in the Yard, with the General Store Keeper, and 2 Invoice and dispatch Keepers to the separate departments of the Iron and the Timber Yards. —

"The 3 Mootsuddies would be used on detached duties and in preparing monthly [?] reports. These men would also look to promotion to the higher appointments. The Chuprassies and Sweepers could not be dispensed with, the former for the Superintendent and Deputy for messages and other purposes, the latter for the cleansing of the Office and rooms. —

"After a careful examination of the returns and duties of these Ships, I don't think that the above Office Establishment could possibly be placed on a lower scale. I beg however to suggest that upon

the

the presence of an efficient Book
Keeper without whom there will
be neither order nor regularity —
It is moreover economy to make
liberal arrangements for an Office
of this sort, upon which so much
of our success depends. —

[The list of Establishment
furnished for the [illegible]
Yards is supposed to meet the
[illegible], if kept at work
up to the full means allowed by
the machinery and extent of the
yard and shop accommodation.
The establishment of the members
of the different grades would be
[illegible] [illegible], and would
not be acted upon all at once]

The Foreman and [illegible]
Assistants ought to be well educated
[illegible] and [illegible] to
[illegible], and under [illegible]
[illegible] [illegible] as to duties, as
long as they were confined to the
[illegible] [illegible]. Agreements
[illegible] [illegible] [illegible]
[illegible] little, appear to be [illegible]
[illegible] [illegible] it has lately been
experienced in the Roorkee workshops;
where a man who in his written
[illegible] professed to serve as an
Assistant Practical Engineer, and
who from the position of Roorkee has
not only had his passage from
Calcutta paid by the Government
but has received 3 months salary
in advance, has used on his arrival
at Roorkee to do work excepting
under his own '[illegible]' as he calls
his own view, of the duties of an
Assistant Practical Engineer. —

To the Establishment pro-
posed for the Timber Yard the
[illegible]

remark made above on the subject of its being sufficient for present demands, and of its gradual en-largement, equally applies. [illegible] [illegible] I would add, from [illegible] practice and [illegible] [illegible] [illegible], I have no doubt that [illegible] would be easily selected [illegible] from the Army; these men might remain on the [illegible] as Assistant [illegible]. [illegible]

I do not [illegible] it necessary to recommend any immediate selection [illegible] officers [illegible] [illegible] which is recommend-ed for the [illegible] [illegible] experiment, and [illegible] as well the means of [illegible] data than we have at present [illegible]

To the above memorandum the following abstract of the expenditure proposed to be incurred both in [illegible] accommodation and monthly establishment [illegible] is [illegible].

Buildings for Mathematical Department		5000	
" Foundry		10000	15000
Tools &c " Mathematical Dept		4000	
[illegible] Apparatus	do	11000	15000
Total Original Expenditure [illegible]			30000
Current Monthly Expenditure			
Supervision	Salaries	800	
	Marching allowance	100	900
Office	English	425	
	Native	124	549
Practical Working Establishment	Iron Yard &c	1600	
	[illegible]	1009	2609
Total Cost of Monthly Establishment [illegible]			4058

The [illegible] Establishments which up to the 31st October 1857 existed as a component part of the Carriage Manufactory, were, on the 1st November following, on the commencement of an official year, separated from them, and placed under the superintendence of Lieut. Allan [illegible] to be conducted on the footing of the Carriage Manufactory, as an Institution for the use of the North West Provinces, under the following orders.

That there should be a small [illegible] Instrument Depot and Establishment, for the supply of all Instruments to the Provinces North of Allahabad, that requisitions shall be made on Calcutta, that under the [illegible] sanction [illegible] the consideration of [illegible] those of other Departments [illegible] of the [illegible] Military Board.

That there shall be an [illegible] and [illegible] yard for the purpose of supplying [illegible] can be done economically as articles required by the Public Departments. That this [illegible] Yard should relieve the Gun Carriage Agency at Futtyghur under [illegible], in the manufacture of [illegible] in Ordnance, improvements, Locks, &c., in the supply [illegible], and a variety of [illegible] articles supplied from England and from the Commissariat Department. 2nd [illegible] Collection [illegible] to the manufacture of Fire Engines, Forge

and their Implements, weights, measures, moulds, models and patterns, Lathes, &c. and it should be a means of supplying to the Country at good serviceable articles at fair rates on private purchase for private purposes.-

That there should be a Foundry for the purpose of supplying Castings to the provinces north of Allahabad and of being of general service on emergency. For this purpose the Establishment above recommended was sanctioned: with a scale for the Foundry as follows.-

1 Foreman		150
1 Head Mistry	@ 30 Rs per month	30
4 Asst do	@ 15 Rs	60
2 Carpenters	@ 10 Rs	20
6 Labourers Coolies	@ 4 Rs	24
Total Establishment for Foundry		384

For the purposes of the most ... above Mathematical shop and Foundry with other subordinate buildings, which the circumstances of the case appeared to render necessary, especially in ware-house room and extended accommodation for the shops in general, the following amount of expenditure was authorized.

Mathematical Shop buildings	6000
Tools for do.	4000
Warehouses, Foundry, with Contingent Buildings	15000
Total Company's Rupees	25000

Cummins

With a reference to deliver on receipt and distribution it was determined that all Instruments received from the Magazines or Public Departments, whether new or old, should be transmitted in the first instance direct to the

Superintendent

ey, [illegible] at the Work Shops, to be [illegible] examined and in necessary repaired. The Superintendent [illegible] satisfied himself that the Instruments so issued were in perfect order, and in a proper state for distribution, should have them over to the principal of the College taking his receipt for the same. The Principal would then act on the report of a Committee assembled for that purpose, after such might be considered sufficient for his own examination, receive them into the Depot, and from thence issue them to the different Departments; on the countersignature of the Surveyor General in the case of the Survey Department, or that of the Military Board otherwise. — This will of course necessitate the building of Store rooms which is included in the above Estimate of 6000 Rupees, 1000 Rupees in addition to my original Estimate having been added for that purpose.

For the increased quantity of Stores for which the new system would call for in the Timber and Iron Yard, an additional 5000 Rs which is included in the third item of the detail of cost above given was added to the Estimate. The arrangement for the receipt and distribution of these Stores was that they should be issued (as is at present the case in the magazine) on Indent countersigned by the Military Board; Emergent Indents being (in consequence of the distance at which the Board is situated from Roorkee) immediately attended to by the Superintendent who is to report the same without

[illegible]

-ions of [illegible] to the Military Board. With regard to the Ganges Canal works it was ruled that they should hold a prior claim upon the Roorkee Workshops, and that their demands for worked stores should supersede all others; and that the Officer or Officers holding Executive Charge of the Northern Division, subject to the Director and Superintendent General of Canals, should have unlimited power in procuring the aid of the workshops, and that calls from these functionaries should be attended to in preference to those from any other quarter.

The system of Accounts which I recommended was that adopted in [illegible] as carried on by private Individuals; the plan of which was suggested and the detail drawn up by Mr [illegible], the head assistant in the Office of the Director of the Ganges Canal Works, whose plan of Accounts for the Department of Public Works was so highly spoken of by the Committee of Enquiry into that Department under the Presidency of Major Kennedy. This plan of Account keeping will be found in the Volumes of Tables.

The design of Accounts and the system of dealing with Individuals public or private, was to get rid of the delays which had usually accompanied the purchase and receipt of Articles through the Military Board. Cash payments and settlements

settlements of account for articles supplied, instead of procrastinated paper records, with settlement indefinitely postponed, were the corner stone and basis of the whole structure; it was founded on the propriety of having all accounts settled at once, of making the Shop at Roorkee a depôt from whence all im-plements and stores required for the Public Works may be purchased by Executive Officers, who would own, pay for, and charge to their Account at once in the Bills for works upon which they were engaged. It would relieve the Executive Officer from the anxiety of a position which he has always held, as to the Balances against him in the Ordnance Books; he would proceed from year to year, with a clean Balance Sheet and when his departure from Office, or period for taking furlough arrived, he would at least be free from any anxiety on the subject of unexplained arrears.

[illegible] the 1st [illegible] 185[illegible] Hence the Workshops at Roorkee commenced a new series of un-important duties although their connection with the Ganges Canal works then in progress, and their occupation on Wood and Iron work solely for Canal purposes would for some years curtail their general usefulness. The enormous demand for [illegible] not only for the Solani Aqueduct and the works directly apper-taining

-taining to the Ganges Canal, but for the College buildings and numerous Bungalows under construction for Students rendered it quite impracticable at that period to make any active movement in the buildings which was called for by the newly organized Institution. At that time therefore the Shops were necessarily limited to their engagements and to the accommodation that they previously had. The designs for the New buildings however were placed in the hands of the Executive Engineer so that when opportunity offered he might carry them on, if only by slow and gradual means. This has in fact been done, the Machinery stores on the Northern face and certain other buildings attached to the Foundry and Mathematical Department have been in slow progress. The clearing off of the Solani Aqueduct works and the completion of the College buildings both of which unfortunately had to be simultaneously carried on, will lead to the rapid finishing of all the buildings and improvements required for the Shops. —

In the meantime the arrangements for the receipt of Instruments from the Magazines and the Establishment of the Depôt at the College have been necessarily placed in abeyance. In fact at the period that I am writing, although a good deal of the initiative proceedings have been gone through, and the ground work has been laid for ultimate progress, the workshops are [illegible]

sentially in their infancy and may be considered as by no means introduced to the Public as an established instrument for general use. -

Before closing the account of the Workshops in their new position, I may remark on the arrangements for money advances and the possession of Capital, as we may term it in this case, which the Superintendent of the Shops holds for carrying on business. -

As, on the separation of the Shops from the Ganges Canal Works nearly the whole of the work done by the Shops was for the Canal, the Executive Engineer of the Northern Division of the Works was directed to make advances of even sums of 10,000 rupees, these sums being, in fact advances on a running account that must necessarily exist between the Canal and the Workshops. The same system would be adopted where any public Establishment drew largely or regularly on the Roorkee Workshops for supplies. Advances for instance must be made to the Shops for the manufacture of Fire Engines, Lathes and Tools, for which orders are received from the Military Board. In the latter case, and in all others where Articles are manufactured for the general purposes of the State, these advances would be made by assignments given by the Accountant General to the Work Executive in the same form as

in manufacture

assignments are now given to the Canal Department for Current Expenses: viz: by application by the Superintendent of the Workshops to the Director of the Ganges Canal Works, who would hold in his hands the power of acting on an Annual Assignment granted by the Government on an Annual Estimate submitted by the Superintendent of the Workshops through the Director. The Amount of this Annual Estimate in the early period of the Shops operations must necessarily have been uncertain. It was clear that if advances were received in the Workshop Treasury from Public Departments for everything manufactured for their use, or if every [illegible] general use [illegible] thing sold to the Public, the only assignments that the Government would be called upon [illegible] would be a certain Capital in the first instance to carry on the manufacture of articles and for monthly Establishment. The first of these would be gradually decreased in amount as the sales of Articles took place and the latter would in all probability cease, from the Factory being able to pay its Establishment from its own receipts. At the commencement and during the early period of progress, the following arrangements were determined on.

1st. All purchases of Stores such as Iron Timber &c should be made on Estimated advances

for which an application for an Assignment would be submitted by the Superintendent on the 1st of May annually

2nd That all Purchases of Machinery or implements required for the different Departments of the workshops should be procured in a similar way; in the way in fact which is now done elsewhere, viz. by submitting an application to Govt for permission to purchase, and by obtaining an Assignment for the purpose —

3rd That until we are able to settle down [illegible] at present the average cost of Labor and Sundries for the last 12 months including the increased salary to Superintendent &c should be taken as the probable monthly expenditure on these items, and that power should be given to the Director to grant periodical assignments in sums the total of which should not exceed that monthly average.

Average expense per month on Labor and Sundries	6500 0 0
Do on Regular Establishment	1500 0 0
Total per month Rs	8000 0 0
Total per year Rs	96000 0 0

The total per year as above noted, being the Amount of expenditure for which an Annual Assignment will be granted.

On the above rules and with the Authorized Sum as above noted the Workshops have been carried on up to the present period. On arrival the [illegible] succession to the Practical Engineer

[illegible]

who accompanied me from England and who returned at the expiration of his service, as well as that of a very superior workman in the Mathematical Instrument Department, have placed us on an excellent footing in preparation for more extended proceedings on the completion of the new accommodation. The former, Mr Watson gives promise of being a great acquisition in all departments; he has established the certainty of success in Iron casting and has built a small Cupola temporarily erected, doing a good deal of work, which must otherwise have been made at a distance. The latter, Mr [illegible] was a long time in the Surveyor General's Office in Calcutta, employed in the repair of Philosophical and Mathematical Instruments, and even with the want of room and convenience which he has experienced, he has turned out articles in the shape of small surveying Circles or Circumferentors for the use of the Natives, and other descriptions of common Instruments that would do credit to the professional artist of London. I believe that these shops only require to be completed, with proper accommodation for the different departments to which they are destined, to do full justice to the intentions of the Government.

Early in 1853, the following machinery in addition to that which was formerly received was ordered from England

A 90 Horse Power High pressure
Beam Steam Engine
A Cutting and punching Machine
A Small Rolling and Boring do
A Small Planing do
A Plate bending do
A Large Self Acting Lathe.

The Engine will be attached to the Foundry yard and in connection with the Machine Department, and it is by no means improbable that it will be found convenient in economizing space to remove the northern wall of the Old Quadrangle or Iron yard and by so doing, to throw the Foundry and the Quadrangle area into one enclosure.

My original idea of having Quays and fixed Cranes on the side of the Canal in connection with the Workshops will also be greatly improved by a proposal of Lieut. Atkins, viz. the construction of a Dock in the centre of the Timber yard, connected with the Canal by an iron swing bridge over the Canal bank and berms. The site of this proposed improvement is shown in the plan of the Workshops Plate LIX Atlas. It will enable goods to be floated into the yard and give us the means of loading and unloading within the precincts of the Workshops, and in the immediate neighbourhood of the Warehouses; it will also give great advantages to our Boat building operations in floating the boats away as soon as they are built. Practically

Stating the continuation of this work will be an economical one, as it will in the excavation for the Dock and Canal of approach to it, give Earth for raising and levelling around in the yards, which [illegible] quite the Quantity of work of this description that was done in the early stage of our proceedings, is very much wanted. The only inconvenience that I see to this side Channel which will leave the Canal at the Commencement of the Dock on the approach to the Bridge, is that its mouth will be a harbour for Silt deposits, and that by opening a passage through the work Drop wall for the Canal ingress and egress will be obtained. In the worst Case, the Silt clearance would be effected at periods when the Canal was laid dry, and the Silt itself if not required elsewhere, would be thrown into the main Canal bed on the down stream side of the Dock Channel head, as it could not be allowed to encumber the Esplanades or road ways. In the latter, provision might easily be made in the shape of a Portcullis or some protective expedient by which ingress into the Yard by that passage would be prevented.

By referring to the maps of Roorkee it will be seen that I have reserved space around to the South of the timber yard, and not allowed it to be occupied by either private or public buildings, the road

road which has been carried across it having been allowed merely as a temporary conve-nience – my object having been to retain the whole of the land in the neighbourhood of and parallel to the Canal for pur-poses of workshops, so that the inclosure or buildings required for its purpose may be collected in one compact mass – That portion of this ground lying in close proximity to the Private Estates on the East, and which lies out of the alignement of the East wall of the Quadrangle has been proposed to be occupied by the Quarters of the Company Establishment attached to the yard; the flat roofed buildings connected with it, on the north East angle of the Boundary, being considered as more applicable to providing additional accom-modation to the shops, than to that of private residences – Thatched roofs and a free cir-culation of air are certainly more adapted to salubrity than a series of connected rooms attached to the body of the workshop Buildings. – The ground at the present time is occupied by Timber, it is separated from the Timber yard enclosure by the high road and ramp of approach to the bridge, an im-pediment which can be easily overcome by a passage of com-munication built under the road – This with the free use [illegible] a quantity [illegible] will on the completion of the Canal

tram is always made, will connect the whole of this extended line of shops and yards in one convenient series.-

Vide

At present the Model Department and Libraries both professional and non professional are under the Executive Engineer of the northern Division of the Ganges Canal Works, although the rooms form a part of the Workshop buildings. These are specifically for the Canal Department, and for study and reference for the Students of the Civil Engineers College. A Librarian for whom a Salary of 40 Rupees a month is allowed by the Government has not yet been entertained. The present State of the Libraries, and the small number of books contained in them hardly called for a substantive appointment of this sort, the duties having been performed by the Head Writer in the Executive Engineers Office on a reduced allowance. A list of the Books will be found in the Volume of Tables.-

The Model Room is at present by no means fully occupied, and its contributions are chiefly Models of works which have been built on the Canals in these Provinces. Its nucleus may be dated as far back as 1831, in the Model room of the Eastern Jumna Canal, which progressed under my successors and ultimately was removed in mass to Roorkee. It possesses, nevertheless, some interesting Models besides those

of Canal works, and as a beginning to a more perfect series is satisfactory.—

The Clock tower, the basement story of which acts as the vestibule from the open [illegible] which lies to the East of the main building, is built on a design by Lieut. [illegible] Price a Deputy Superintendent in the Canal Department, the Architect and Designer of [illegible] the [illegible] and the College; it is a neat frame building campanile fashion, so [illegible] that although in contact with the mass, it is built separate from the main building of which it forms a part. The Clock is an Eight day one made by MacCabe with 4 faces and with a strike that is heard very distinctly over the whole extent of the works.

In conclusion, I may observe that nominations of Officers to the workshops have been confined to those only who have appeared to possess peculiar claims for the Office, vacancies still exist, which may be filled up as opportunities offer, but at an out of the way place like Roorkee, removed altogether from contact with Calcutta or any of the large Towns of India, we are in a measure cut off from connection with men who are fitted to the work, a greater disadvantage, perhaps, is the absolute necessity for procuring men at a great expense from distant points on certificates of character and professional

knowledge.

[illegible]
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knowledge, which experience may point out to be altogether fictitious; this is an evil to which we are open at present, although the extension of railroads, and dependent on them, the introduction of practical Engineers in the Country may place us on a different footing hereafter. In Lieut. Allen as the Chief we have in all Departments of Machinery an excellent Superintendent; in Mr Watson as a Practical Engineer, we have a Young rising man with a great deal of professional knowledge, backed ~~up~~ by other acquirements which render him worthy in every way of maintaining a high position in the workshops. In Mr Ordish the Mathematical Instrument maker we have an equally efficient member of our young Establishment. We require more aid, however, and I consider that this can only be satisfactorily gained, by a deliberate selection of men. The following table will exhibit the present state of our European Superintendence in the workshops with the vacancies still existing. —

Lieut. Allen	Superintendent
" Penn	Acting Expr. Do.
Mr J. L. Watson	Practical Engineer
" H. J. Ordish	Assistant Mathematical Instrument Department
" Brougham	Book Keeper
" Pigott	Asst. Do.
" Pocock	Clerk
Serjt. Neilson	Asst. Foreman Workshops
" McAllister	Store Keeper
Corpl. Aitchison	Overseer

Vacancies

1 Mineral	Master
1 Asst. Foreman	Timber yard
1 Do.	Foundry
1 Clerk —	

Lieut. Read of the 50th Regiment N. I. a Deputy Superintendent in the Canal Department is at the present time acting as an Assistant to Lieut. Allen.—

It does not appear worth while to pay any specific attention to the temporary work-shops that have during the progress of the works been attached to each of the Divisions both these and the Divisions themselves hold tenure merely on the progress of the works, and will be broken up and discontinued on the new organization of the Establishment depending on Irrigation. Their occupation has been chiefly confined to the common routine duties of each Division, making Doors for the Choki buildings, woodwork for the Sluices and Regulating heads. and all woodwork required for Divisional purposes. —

Section II. Mills

The only arrangements which have been made for machinery of this description are for grinding corn, and the machinery itself is the common Punchukke or native Corn mill of these provinces. Buildings for this purpose have either been constructed, or are in preparation for construction at the following places.—

Kunkhul
Buhadoorabad
Sidhnuggur
Muhmoodpoor
} Saharunpoor District.—

Behra }
Jauli } Muzzuffurnuggur Dist.
Chitowra }
Tulawur }
Bhola } Meerut District
Dasna }
Pulra }
Timra } Allyghur District.
Cawnpoor Terminus Cawnpoor Dist.
Etawah Do Do. –

The merit of the Panchukkee is its exceeding simplicity, its perfect adaptation to the natives who are called upon to use it, its excessive cheapness and the ease with which it is replaced or repaired; its defects are loss of power, or requirements for a large body of water than would be necessary with the Turbine. These defects, however, are in our case negatived by the mills being placed in such a position that the water in its progress down the Canal passes through the wheels of the mills, and rejoins the main stream through their waste channels, with the quantity of fall which they require, and with water sufficient for the purposes of the Panchukkee, much as I esteem European ingenuity and invention, I have preferred supplying the native of India with his own simple mill the use of which he perfectly comprehends, and the repair of which he can effect either by his own means, or by those of the nearest village carpenter. Turbines &c., may come hereafter, and will I have no doubt do so with great advantage to the rising generation.

The

Kunkhul

The only deviation from the above rule of the water proceeding through the mill shoots and rejoining the Canal through the waste channel of the mills themselves, is in the Establishment at Kunkhul. These buildings have not yet been constructed, but should they be so, their site, along on the edge of the branch of the Ganges just below the town of Kunkhul, will militate against the above economical principle. In this case the water after passing through the mills will run into the branch, and although not actually lost to waste, as providing the means of irrigation to a quantity of low ground that lies in the neighbourhood, the principle is opposed to the practice which I desire to see accomplished. My only object in fact in establishing the mills at Kunkhul was to give a ready supply of flour to the inhabitants, and I did this even to the neglect of a principle in consequence of the main stream of the Ganges being in such close proximity that additional water might be admitted into the Canal channel to meet the demand of the mills. —

The design for the Kunkhul mills is shown on Sheet XVII, Atlas; it is similar to that found in the Estimate of 1845; it consists of an octagonal Basin with the four alternate faces occupied by mill buildings, the 4 remaining sides acting as the ingress and egress channels. The design gives

gives space for 16 pairs of Stones which will grind in the aggre-gate from 800 to 1000 maunds of Corn a day. — Supplementary to this nest of mills, more es-pecially for the use of Kumbhud the Town of Burdwan will be supplied by detached Mills, which may be built either by the Government or by private Contract on the Branch lying between the main Stream of the Sanges and the regulating bridge and Dam at Mayapoor.

The Bahadoorabad mills are built upon the site of No 1 Lock, as designed in the project of 1845. They are situated below Jowallapoor and the village of Bahadoorabad, at a distance of a mile from the latter. There are arrangements for 16 pairs of Stones, the Mills lie on the right and left of the navigable Canal into which the waste water passes. The head of these Mills is situ-ated on the high levels where the Ranipoor Superpassage and the reservoirs connected with them are supplied with outlets from which water for Irrigation can be delivered to the neighboring village lands. These works are in progress of construction.

The mills at the places noted in the above list from Asofnuggur to Tonna, are connected with the waste chan-nels of the Locks at the different Falls, they are built on one de-sign and in construction the revetment wall connected with the Canal face is so ~~designed~~ laid out

[illegible]

that additional mill buildings
can be added afterwards, should
an increase to the number of
stones be desirable. At each of
the Locks above alluded to, there
are 2 mill houses, each of which
contains 2 pairs of stones; the
supply for the wheels is received
from the higher levels of the Lock,
and the water passes off into
the Lock waste chamber.

The 2 terminal works on
the Cawnpore and Etawah lines
are constructed on a similar
principle to the above. The 4
buildings are, however, detached
from the Locks and have a Channel
from which there are separation
in the [illegible] or [illegible]
[illegible] flanks the Canal Channel
[illegible] [illegible] their supply [illegible]
from the head levels, and pass
off their waste water on the lower
lines. A plan of the [illegible] the
however is that of all. They dif-
fer in nothing excepting in
length of [illegible] depending on
the amount of fall of water
passing [illegible] from the wheel and
in the arrangements necessary
for the discharge of waste water.

I may conclude this
chapter with a short account
of the native water mills, which
was published by me in the
year 1833 in the Journal of
the Asiatic Society, as without
any disrespect to turbines and
other ingenious devices, I have
always considered and do still
consider the Punchukki of the
north west Provinces of India,
a machine possessing ex-
-traordinary

-traordinary claims for adoption amongst a class of people like those with whom we have to deal in the Canal Department.

On the mountain streams and rivers in the Northern Doab, the natives use a water mill for grinding corn, which from its simplicity is well deserving attention. It might be applied in all countries, where a sufficient ~~fall~~ quantity of water can be commanded. ~~[illegible]~~ When a want of efficient workmen renders repair of the complicated ~~and expensive [illegible]~~ machinery ~~[illegible]~~ difficult, the Punchukki would be of great service ~~[illegible]~~. In the hands of the natives and with the rude means at their disposal, it may be perhaps considered the only kind of mill that could be turned by them to any account, ~~[illegible]~~ From the simplicity of its construction ~~[illegible]~~ it can at a trifling outlay be placed or removed at pleasure ~~[illegible]~~. The only weighty parts the Punchukki in fact are ~~about~~ the mill stones, which (by running a stick through them, and yoking to it a Bullock's pair of bullocks) may be removed with as little difficulty or expense as the rest of the machinery.

A horizontal water wheel with floats placed obliquely so as to receive a stream of water from

from a spout or funnel, the said floats, being fixed in a vertical axle passing through the lower mill stone and held to the upper one by a short iron bar at right angles, causing it to revolve with the water wheel; the axle itself having a pivot working on a piece of the hardest stone that can be procured from the shingle near at hand; this with a thatched roof over it, and the expense and trouble of digging a cut so as to take advantage of a fall of water, are the only requirements for this very simple mill. The plan is so obviously good, not only for the means [illegible], but for its possessing a simplicity which renders it almost indispensable [illegible]; it is moreover [illegible] to the parts and [illegible] within the comprehension of the simplest understanding. The Punchayet was [illegible] adopted gradually in all the [illegible] in the [illegible] District as well as in those of the Doab, and with such success, that its introduction is as much an object on account of the profit arising to the landed interest, as from the [illegible] and convenience afforded to the community, in providing the means for grinding corn.

[illegible] reference to the accompanying plate it will be seen that the motion is direct and not [illegible] the [illegible]

~~[illegible]~~, the ~~permanency~~ adjustment of the machinery depends entirely on the lower pivot. It will also be evident that there is not a part of the whole machinery that could not be repaired and put in perfect order by the commonest village workman, a matter of importance in the absence of mechanical skill and practised workmen. Whereas in the plainest undershot wheel applied to a mill for grinding corn, there are no less than 3 wheels of different descriptions, the change of vertical to horizontal motion, and the pivots ~~to keep it in order~~, with friction, even under the most skilful management, tending constantly to disarrange the parts, and render the ~~[illegible]~~ presence of a person able mechanic ~~[illegible]~~ indispensable ~~to keep the wheel in order~~.

On the Canals it has been found worth while to construct permanent buildings for these corn mills, and although keeping most strictly to the original simplicity of the machinery, they are set up with greater care, and means are given for regulating the motion of the wheel, which renders the work as perfect as it can well be.

It would appear that a fall of water (that is to say, the difference of level between the surface of the head supply and the float boards of the water wheel) equal to 3 feet, is the minimum on which this

[illegible]

species of machinery can be used with any good effect, and it has been found that with a fall of three feet, the dimensions of the shoot or funnel require an addition in breadth, to obtain that by weight of water, which the smallness of the fall will not give by velocity alone. ~~and in the dimensions of shoot or even to those of a higher class~~.

The following are the particulars of mills on the Eastern Jumna Canal, divided into three classes depending on the depth of the fall, the breadth of shoot in the sill or wasteboard, being 12 Inches, and the discharge per second averaging 1·5 Cubic feet. The diameter of millstones 27 Inches, and thickness 12 Inches, the grain being ground into Atta or coarse flour.

Class	Fall of Water		Atta ground per hour		
	Feet	Inch.	Maunds	Seers	
No. 1	–	6	1	26	or lbs 182
2	5	6	1	5	" 90
3	3	6	0	17	" 32

The common mills used on the Jumna and mountain streams are said to grind from 2 to 7 maunds of Atta per day, or in 24 hours; the machinery being of the rudest description, the supply of water being very small, and a great part of that escaping through the shoot before it touches the water wheel.

Dawson

The return to Government on the mills is obtained generally by farming them out to Contractors for fixed periods, who pay so much per day as long as

a supply of water equal to that intended in the Contract is provided, regulated by the depth of water on the sill or waste board. This return of course varies not only ~~from~~ with the power of the mills, but also ~~from~~ with their position relatively to populous Towns and Cantonments. In the neighbourhood of Delhi the demand for atta ~~return~~ is great, and the consequent return ~~demand for atta~~ equally so; whereas at other points distant from Towns, mills of equal power ~~would~~ do not produce half the return. The Eastern Jumna Canal, although possessing every advantage in fall and power of machinery, labours under a disadvantage in this respect, the Town of Saharunpore being the only one throughout its whole extent where there is a very great demand for machines of this description. Shamli, although a large Town, does not contain a great number of that class of people who purchase atta, each family grinding their own Corn for home consumption; and although there are ample means for establishing mills at the South end of the Canal opposite Delhi (the Canal falling into the Jumna with a descent of about 50 feet in a line of 12 miles!) it has been considered unadvisable to put them in extended practice, on the supposition that the mills already built on the Delhi Canal, in the City would suffer from the competition; in short, that the mills

in Delhi are sufficient to grind the corn required by its population.

The people from whom the Millers look for profit are chiefly those of the Serai class, travellers, those without families, idlers &c. Those who are regularly settled with their families, trusting ~~[illegible]~~ to the hand mills in their own house, and not purchasing from the Mills excepting on marriages and other grand occasions, when the consumption of Atta is more than their own mills could provide for. In Military Cantonments the whole of the Atta and flour used is obtained from the Mills; the vicinity therefore of a Station of this description becomes a lucrative affair to the miller, [illegible] exemplification of which I may mention, that during the existence of the Provincial Battalion at Saharunpoor the Canal mills at that place were kept constantly in their service, with little or no aid from the inhabitants of the town.—

The profit derived by the renter of a mill depends in a great measure on his management, and on the rate per maund which he charges for grinding; but with an experienced and steady man, the following may be considered as a very close approximation to the daily produce. The rate per maund for grinding Atta by the Pisunharies or women grinders in the city, is generally 3 annas, for which sum they deliver the Articles at the purchasers

house

house; at the water mills 2 annas per maund is the usual charge, not however, including the carriage of the grain to the millstone, the charge of 2 annas being simply for grinding.

The expenses to the miller for keeping 2 mills at work are thus:—

Per month	1 Head millers wages	5	"	"
	1 Assistant do	4	"	"
	1 Weighman	4	"	"
	Oil at ½ [illegible] a day about	1	"	"
	2 Seers of Atta given per day to 2 millers in addition to their regular pay. about	2	7	"
Total Expense per month		16	7	"
or per Day taking a month of 30 days		"	8	75

The receipts per day are as follows:—

Supposing 55 maunds of flour ground @ 2 annas per [illegible]		6	14	"
Deduct				
Expenses as above	0 8 9½			
Government rent	5 0 0	5	8	9½
Balance profit to miller per day Rs		1	5	2½

~~Still the above daily expenses would not be increased by~~ An additional (or 3d) mill would increase the profits to the Contractor ~~[illegible]~~ without a proportionate increase to the expenditure ~~[illegible]~~; whereas a solitary mill would ~~[illegible]~~ require the same establishment as that noted in the above table ~~[illegible]~~ and be less profitable. Mills of a higher power also might be easily worked on ~~with~~ the above scale ~~of establishment~~.

At Mills distant from towns the payment for grinding Corn is made in kind, varying from 2 to 4 Seers per maund; which at the usual rate of from 40 to 50 Seers per rupee, is but a moderate return in comparison with that at the Town mills.— These village mills grind gram barley and Indian Corn as well as wheat.—

The

The Stones used on the Canals are chiefly those from the quarries near Agra. Rooppbas, and Futtehpoor Sikri, a coarse grained sandstone which requires the chisel every second day. There are 3 sizes used

1st Size	Diameter	36 Inches	– Depth 12"
2nd "	do	30 "	do
3rd "	do	27 "	do

the two latter are in most general use. Stones of the usual quality last for about 2 or 3 years, that is to say, at the end of that period a new upper stone is provided, and the old one placed below. In the native mills on the Jumna, stones about 22 Inches diameter, and from 11 to 12 Inches thick, are quarried in the vicinity of Daffoon, with [illegible] they appear to [illegible] superior though of various qualities; the native millers, however, prefer some of them to the Agra stones, and it is not impossible that stones of the best variety from Daffoor may be superior to the worst from Agra, but generally speaking the preference is decidedly in favor of the latter.

The best method of delivering the water from the shoot into the float boards, appears to be that represented in the accompanying sketch and which has been generally practised on the Canals in pursuance of the usual mode adopted by the natives. A trial made at Hansi, in which horizontal (or nearly horizontal) shoots applied to the lower part of

of a cistern delivered the stream on float boards whose planes were parallel to the axis of the arbor or upright, did not answer so well as was expected, owing in a great measure, it was supposed, to the introduction of a new system, which unless palpably advantageous, is certain to meet with objections from the people to whom the Mills are intrusted. I am much inclined to consider that the latter method is not only objectionable but that the power obtained in applying it to this simple water wheel is much less than the other, a matter to be settled by practical experiment and not by theoretical speculation. Belidor, in speaking of a Mill of this description, says, "En Provence et dans une bonne partie du Dauphiné, les moulins y sont d'une grande simplicité, n'ayant qu'une roue horizontale, de 6 ou 7 pieds de diametre, dont les aubes sont faites en cuillerès* pour recevoir le choc de l'eau, qui coule ordinairement dans un auge; L'arbre, qui repond à la meule supérieure, est la seule piece qui sert à lui communiquer le mouvement, et je ne crois pas qu'il soit possible de faire un moulin à moindre frais; il est vrai qu'il faut pouvoir menager une chute comme celle que l'on voit ici, et qui sont tres frequentes dans [illegible] pays là.

La

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* These Cuillerès, or spoon-shaped ends, are mere indentations in the Native Mills, and the trough alluded to by Belidor for the delivery of the water at an angle of about 25° is in the Native Mills a square tube or shoot placed at an angle of 45°. The Crapaudine and the arrangement for raising or depressing the upper stone by the transom in which it is fixed, is also practised in the Native Mills

"La roue tourne sur un pivot dans une crapaudine pratiquée au milieu de l'entretoise du chassis, servant à approcher les deux meules, par le moyen de la vis se qui est a l'extremité de la piece, et de l'ecrou, que l'on fait tourner pour hausser ou baissir le chassis

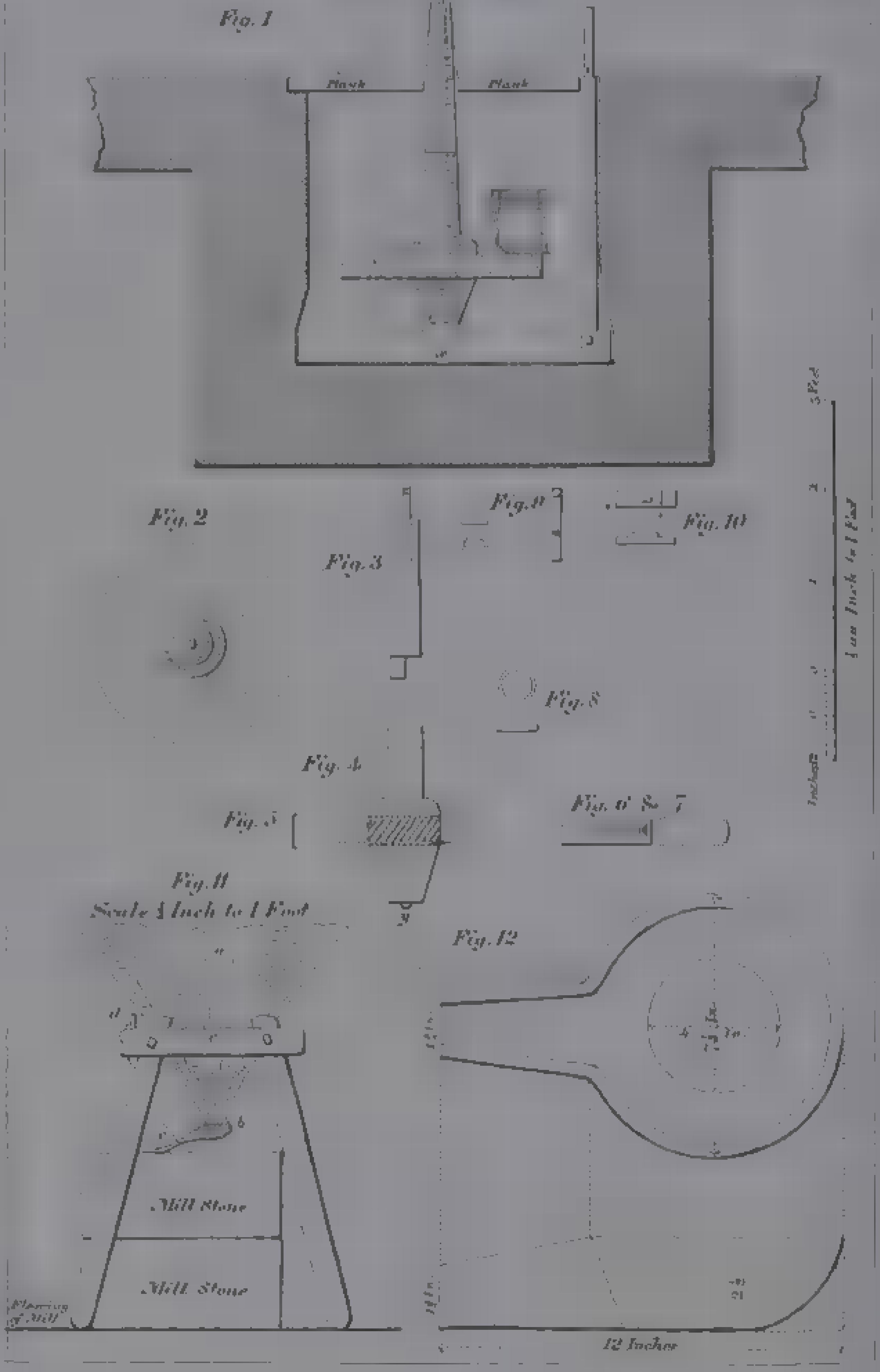
"Les roues que l'on voit exécutées danse la gont de cell ci ont leur cuilleries simplement assemblées a l'arbre par un tenon et une cheville, fortifiées par le dessous par des membrures qui les entretiennent toutes ensembles". He goes on to explain a method of opening and shutting the water course or Shoot, which is of no consequence here. It will be seen, however, that the Provence Mill is exactly on the same plan as that used in this part of India, and it is a pity that the account does not go on and explain the power of the Mill, that we might draw a comparison between the two. It would also be interesting to know whether the increased size (the Provence Mill being about double the size, in diameter of water wheel, &c.) or would not detract from the simplicity of the little native Mill, for the great advantage of the latter appears to be the absence of complicated wood and Iron work, especially joints and iron bindings, &c. all of which increase with length of lever, or length of radii of the water wheel. Indeed the above account shews a complication of Membrures, &c. which in the Native Mill is not thought of".—

Diag: CXXVII.

SKETCH OF WATER MILL

for grinding Corn

as used in the Northern Doab



References to Plate

II [illegible]

Fig: 1. Elevation of the water wheel, with the stones in section to represent the iron spindle.

At x, a hole of about 4 inches diameter and 4 inches deep is made in the transoms into which a Quartz boulder is firmly fixed; the sand stone or boulder having an indentation made in it to receive the pivot.

This pivot, as represented in Fig: 4, consists of another stone of the same quality of about 4 or 5 inches long and 1 inch square, which is firmly fixed into the tail of the arbor (see y). The above stones are picked up in the beds of the mountain rivers, and are used as they are found without any stone cutting.

Fig: 2. Plan of waterwheel. 30 float boards of Sissoo wood.

Fig: 3. Upper joint of arbor.

Fig: 4. Lower joint of arbor, showing the Iron straps fixed between each float board, to keep them firmly in position, the strap represented in Fig: 5.

Fig: 5. Strap as above.

Figs. 6 and 7. Float boards and end of ditto. the float board 12 inches long, with a spoon bench 4 inches.

Fig: 8. Iron ring that slips over the top of arbor, and holds the two joints together.

Figs: 9 and 10. The spindle and plate upon which the upper mill stone turns.

Fig: 11. Sketch of mill stones with basket stand, &c.

a. Hopper or basket.

b. Shoe.

c. Feeder, or small piece of wood hanging to one lip of the shoe, and resting on the mill stone, each revolution of which gives the shoe a jog, causing the corn to run constantly from the hopper through the shoe.

d. String attached to the opposite lip of the shoe, to which the feeder is, and by tightening or loosening which, the discharge of corn is regulated.

e. Stand.

Fig: 12. Shoe on a large scale; this is generally cut out of a block of Dhak (Butea frondosa), or any wood easily worked.

Willshire

CHAPTER VIII.

Terminal Works

This chapter may be divided into the following..

Section I. Works at the Cawnpoor Terminus
II Do Etawah Do
III Do Termini of the Branches
A. Futtigurh Branch
B. Boolundshuhur — Do —
C. Koel — Do —

Section I. Works at the Cawnpoor Terminus

The works connected with this section commence at a point 5 miles 750 feet from the Ganges near the village of Dubowli, the leading one being an Escape for the purpose of regulating the water on its approach to the Town and Cantonments of Cawnpoor, through which the Canal is carried in its descent to the River. The Dubowli Escape is in fact the work by which the Canal supply is regulated in the various Locks ([illegible]) of which the Terminal works are composed, and it naturally takes the precedence both from its position and from the services which it is called upon to perform.

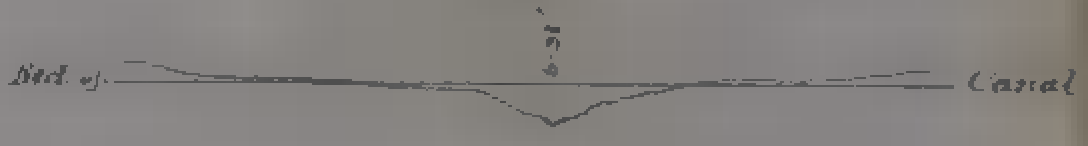
The Dubowli Escape (plan and section of which are given in plate XLII of the Atlas), is situated at a point 1118 feet below the [illegible] Bridge, or that by which the High Road between Cawnpoor and Kalpi crosses the Canal; it

is built across a tributary of the Pandoo River, which lies 8000 feet on the right, and it combines with its services as an Escape for Canal water, a passage for the drainage of the Tributary across which it is carried.—

The Canal Channel at this point is an Aqueduct, the drainage which is collected from a hollow of about One square Mile in extent, immediately on the left of the Canal Embankments, passing by arched Channels underneath the Canal.—

The Valley or hollow over which the Aqueduct passes is shewn in the following diagram, the horizontal line representing the level on which the bed of the Canal runs, with reference to that of the Nulla.—

Diag: CXXVIII



From its intersection by the Aqueduct to the Pandoo River, the Nulla has a slope of 15·6 feet on a total length of 10000 feet; its course is tortuous, with a deep and narrow section, which on its junction with the Pandoo assumes the character of a Ravine; the great depression of the bed of the Pandoo however below that of the flooring of the sub Channels at the Escape, renders the back water arising from high floods quite harmless in its effects upon the Canal works.

The rain water collected at the head of this line of drain-
-age

-age is inconsiderable, the Catchment basin lying above the Canal not exceeding, as I have before remarked, one square mile in superficial extent.—

For the passage of the drainage water collected in the basin 3 Bays of 6 feet each in width and with a height of 4 feet from the flooring to the soffit of the arch have been given on the upstream side; the floorings themselves being built with a rapid slope, so that the discharge outlets in the down stream direction have a height of 6 feet. This slope of 2 feet is on a length of 107 feet, or on the whole width of the building.—

An inspection of the plan will convey a much better idea of the design of this work, than I can give in a written description; it will be sufficient, therefore, to observe that the channels above described become the receptacles of the escape water from the Canal on the upper levels, through a series of side openings. 3 of which are situated on each side of the Canal; the total width of Escape waterway thus provided being equal to 36 feet.— These side openings of 6 feet each in width, discharge their water down perpendicular drops which open into the lower channels, the fall and momentum of the fluid being broken by bars of stone placed across the upper part of the drop, and by wells or reservoirs below, which receive in the first instance the body of water and ease off its action before it proceeds onwards down the bed of the

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the Nulla.-

The Slope which has been given to the waste Channel floorings, and the increased capacity which has been obtained to the Nulla itself, by widening it out from the downstream side of the building, as far as the junction of the Nulla with the Jamdoo, render the Escape both for Country and Canal drainage purposes very efficient.-

The external faces of this building are flanked by Semicircular Revetments, which on the left bank are surmounted by houses for Store and Choki purposes.-

The Canal Channel which is 20 feet in width has on each side a berm of 10, with a roadway of 20 feet in width, the whole forming a compact body of work, with steps of approach to the water in the Canal Channel.

I may here observe that the berms which on the whole line of the Canal had been raised 8 feet above the bed of the Canal are from the Kujoori Bridge to the Dubowli Outlet gradually diminished until at the latter work they stand 6 feet above the Canal bed; at this height they continue throughout the whole of the Terminal works which I am now describing.- The Canal Channel on its approach to and departure from the Masonry work of this building, is carried over well made and carefully consolidated Embankments, to which the Semicircular form of wing Revetments is well adapted.-

There

This work is composed entirely of brickwork, along with the Cement known of the following proportions

4/5ths Kunkur Lime
1/5th Soorkee —)

The quantity of Cubic Feet of the building is 48426.

The rates per 100 Cubic feet was Cos Rupees 16.. 6.. 3 and the total cost amounted to Co's Rs 9241.. 13.. 9

The Dubowli Escape was built by Lieut. Hodgson of the Engineers.

At a distance of 1207 feet below the Escape is the Dubowli Bridge. On the upstream side of this work the Rajbuha head leading to the limits of Irrigation lying between the Paindoo and the ... is situated. (See Plan Plate XLIII)

The Bridge itself is for village purposes, but ~~[illegible]~~ the works attached to it are ~~[illegible]~~ ~~[illegible]~~ designed for Escape as well as for ~~[illegible]~~ Irrigation. Here we have a drop gate which being placed immediately below the Rajbuha head and across the Canal channel acts both for the purposes of regulating the supply of water for Irrigation and for preventing the onward passage of water towards the Roorkee works. In the latter case the 6 openings at the Dubowli Escape, as well as that for the Rajbuha become the outlets for the waste water, the Rajbuha playing its part ~~[illegible]~~ any water that may fail to escape through the six openings at the Dubowli Escape.—

The

[illegible]

The Rajbuha head at this Bridge is the last opening for irrigation on the Cawnpore termination line, its width is 10 feet and its sill or flooring is on a level with the canal bed. The opening in fact is so devised that in case of necessity all spare water may pass down the Rajbuha channel, whilst ~~land of~~ the main line on the downstream side of the shutter is laid perfectly dry. —

The design of this bridge is plain, a 70 feet segment of 60° for the Canal Channel, with side towing path passages of 4 feet in width, flanked by ~~plain~~ rusticated pilasters, ~~[illegible]~~ — The width of roadway is 18 feet and steps of communication between the high and low levels are attached to both the up and down stream wings. The front of the Rajbuha head, as well as the opposite side of the channel, are covered as usual with flights of steps and the fish walls of the berm is secured by a retaining wall on the same plan as has been designed at the other Bridges. The masonry Channel on the upstream side of the bridge is laid out with reference to the best plan for directing the current upon the head of Rajbuha.

This work is built of brick masonry with cement of the following ingredients

4/5th Kunkur Lime
1/5th Soorkee

The cubic contents is as follows.
2518 — cubic feet

the rate per 100 Cubic feet of masonry was Company's Rupees 17..6..5 exclusive of Plaster &c and the total cost of the work was Cos Rs 5010..1..7-

The work was built by Lieut Hodgson, the Executive Engineer of the Cawnpoor Terminal line.

The Dubnapoor Bridge is that for the passage of the Grand Trunk Road between Allahabad and Allygurh, is situated 14176 feet below the Deboroli Bridge above described, it is similar also in design **with exceptions** ~~[illegible]~~ in the width of towing path passage being 5 instead of 10 feet; and in the latter having segmental instead of circular arches.

This Bridge is built on a skew at an angle of 65°, corresponding exactly with that on which the Road and Canal intersect each other. The width of Roadway is 25 feet, and the up and down Stream faces in connection with the Canal Channel are flanked by semi circular revetments adapted to the towing paths.

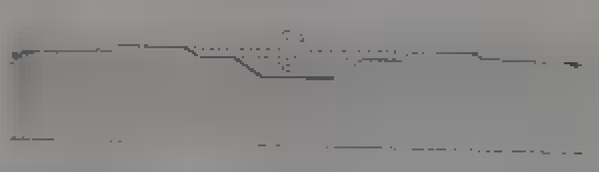
On the whole of the line of canal upon which the works above described are situated the course has been on a gradual curve, directed upon the boundary separating the City of Cawnpoor from the Military Bazar of the Cantonment. The depth of Excavation varied from 8 to 16 feet and the soil is good especially on the

[illegible]

surface, in the immediate neighbourhood of the Dulknapoor bridge and the Grand Trunk road the existence for a long period of Brickkilns, is a proof that the subsoil at least is formed of good brick earth.

After leaving the Dulknapoor bridge the Canal runs for a length of 3744 feet, still in a curve, through a good deal of broken ground arising from the Brickkilns above mentioned, until it reaches the angle of the City at which the leading bridge, or No 1, connected with the series of works which continues to the Ganges River, is situated. On the upper stream side of this bridge the Channel passed through an extensive hollow ~~arising from~~ caused by the excavation of earth for brickmaking, here there was a necessity for a good deal of artificial embankment, but the soil is good, and the brick kilns or native puzawas which lie on the right and left of the line provided an ample supply of material for all purposes. The berms as I have before mentioned are continued at 6 feet in height from the Canal bed, and the Section of the Canal from the Dubowlee Escape to the point at which we have now arrived may be understood from the following diagram. —

Diag CXXIX



The Canal from the Head of

the

the [illegible] works at the Dubouli Escape to this point, passes through an excavated Channel, on a gradual curve, the total length being 1915 feet. Onwards and in advance to the Ganges, the length being 7973 feet the sides are revetted with masonry, and fitted with the necessary accommodations for giving access to the water, to the Inhabitants of a populous Town. Up to No 1 Bridge also the line having been carried through open Country, was attended merely by the remission of revenue for land appropriated; in advance house and garden property had to be obtained by purchase, the width which was considered necessary for Canal purposes being 285 feet.

The whole of the area occupied by the above space is situated within the boundaries of the Military Cantonment, the householders having no claim to the land, which they held on the usual terms as tenants at will, remuneration for value of property moveable or immoveable being paid for on the land being required for Government purposes within the limit [illegible].

The Estimate of Rs 1800, for the value of property thus required, was formed on returns submitted by the Executive Engineer, whose data were necessarily imperfect, and who had neither the means nor the power of entering into details. The width of space was, moreover, under estimated as well as the extent of buildings. During the cold weather of 1850/51 a Committee was assembled for the purpose

purpose of determining the amount to be paid for a portion of the land required for immediate operations closed their labors, with a Bill against the Government of Rupees 67/167-7-5. The valuation was made very fairly, each house or tenement being measured, and the calculated cost of labor, as well as the probable value of material being taken into consideration. The latter item was undoubtedly a high one, and founded on assumptions which were by me never expected to be realized, nor were they so in the result. Extravagant claims for materials in foundations which did not exist, assertions of undersunk wells in the proximity of the river, and varieties of demands for original expenditure of which there were no external traces, and no proofs of their existence, were received by the Committee with a liberality that, as Director of the works, and, therefore, as the guardian of the interests of the Government, I viewed with some degree of jealousy. The full amount of the claims, however, as recognized by the Committee, was approved of by the Government, and the money has been paid with the exception of a small sum for which at present no claimants (strange to say) have come forward.

Hull

In the cold weather of 1852/53, a second Committee completed the settlement of the remaining property that came within the limit of the Canal boundaries

boundaries. This included certain estates or compounds formerly held by Military Officers, which had merged into the possession of Natives, and which by lying on the borders of the Canal in the neighbourhood of the Locks, were desirable as sites of mills and machinery. The arrangements made by this Committee were similar to those of the former one, and the amount of the bill in this case was Rs 22896.4.0

It was fortunate that within the area of the ground which it was necessary to occupy, there were only two buildings for religious purposes. One a Mosque (Musjid-[illegible]) and the other a Mundil (Hindoo). The position of these two buildings is shewn in the map. Both of them have been allowed to remain and although they interrupt the alignment of the works, they may be considered as in no way interfering with their usefulness.

I may mention that in addition to the above payments, permission was given to the owners of houses to remove any fixtures for which they had a particular fancy; carved woodwork, Doors, and all ornamental work whether of wood or metal, were not only carefully removed, but given gratis to the original owners.

The material in fact, which was recovered from the buildings, and others of ~~[illegible]~~ their destruction, was carried to the account of the works, was [illegible] requiring unusual [illegible]

to its value as accorded by the Committee. No indications of Material swallowed up, no impoundations were discovered, the paucity of permanent buildings in the shape of Kiln burnt bricks, was remarkable even to those who knew that native bazaars and Native buildings consist of wood and grass, and are raised at the smallest possible expenditure of money. With the exception of a very few so called pucka houses, which in their detail of construction were generally of kutcha made of mud faced with bricks, the whole of the bazaar that came under our clearance, was a mere collection of mud, taken out of holes which scattered about its neighbourhoods, engendered miasma, pits of filth and stagnant water, nests of miasma, and reservoirs of offensive abominations.—

It is worthy of record how far the value of material resulting from actual work, in its possession and use in the work, tallied with the estimated amount as paid to the owners by the Government. I shall merely give an abstract of the figures in this place, as I have placed in the volume of tables the whole of the detail both in plan and figures by which the estimate was arrived at.

	Estimated value			Actual value of Materials
	Labour	Material	Total	
1st Comm. to 2nd do.	20183 1 7	26999 2 10	6716 7 5	8936 12 11
	Bal.		[illegible]	
	Totals	Rs. As.	47066 0 5	8936 12 11

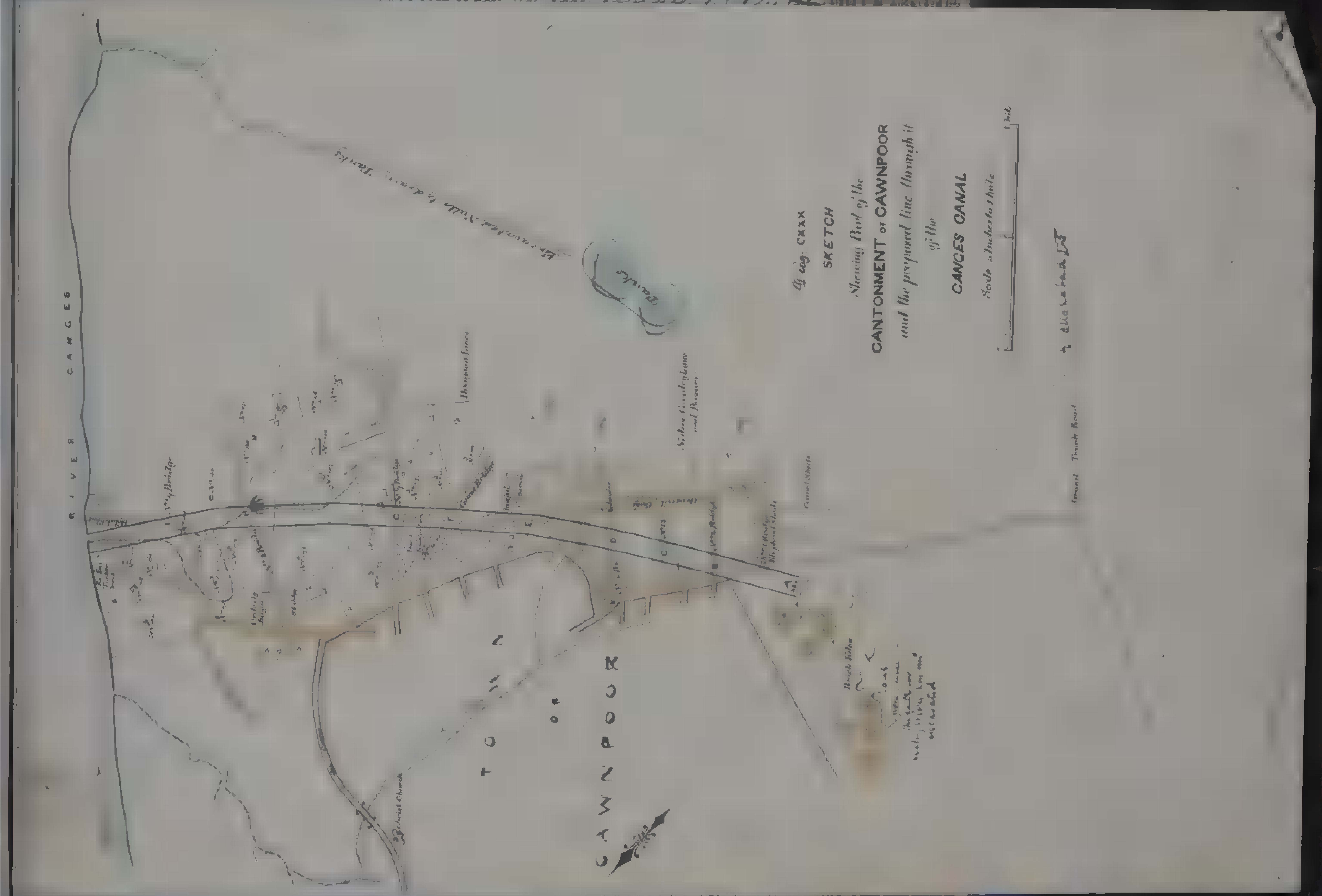
All the Bricks that were fit for use, were put into the Canal works, ~~and~~ the full price (and a very high one too) of the market of the day, having been paid for them in the above table. The same may be said of the Timber and other materials, those which were not required being sold by auction.

The total Amount paid for houses and property which fell within the limits of the Canal boundary from the No 1 Bridge (to which I have before alluded) to the junction of the Canal with the Ganges, i.e. on a total length of 7,775 feet and breadth of 280 feet amounted to Rs 90,061. 0 5; a sum it must be recollected which is totally independent of the cost of [illegible] in the preparation of the [illegible] for Canal Excavation.

I have in the 2nd part Chapter II section III explained my views on the Ganges Canal in its connection with the Town and Cantonments of Cawnpore, and have shortly described the design & construction of the works, with the plan of Esplanade upon which I place great stress, as one tending much to the appearance of the Canal, and more to the convenience and salubrity of the neighbourhood. I shall here enter into greater detail as connected with the buildings themselves, and with the whole of the operations that took place during their construction.

The plan on the opposite page

page is a fair representation of the ground with which the engineer must come in contact. On its western side the boundary of the Town



there is a good deal of building besides a considerable surface consisting of either open spaces belonging to the Cantonment or cultivated land beyond it. The whole embracing an area of nearly two square miles, acts as a catchment basin which is drained by two well defined nullas meeting each other in the Town

and

All the Bricks that were fit for use, were put into the Canal works, ~~and~~ the full price [illegible]

[illegible]

[illegible] I place great Stress, as one tending much to the appearance of the Canal, and more to the convenience and Salubrity of the neighbourhood. I shall here enter into a fuller detail as connected with the buildings themselves, and with the whole of the operations that took place during their construction.

See plan on the opposite page

page is a fair representation of the ground with which the Regiment came in contact. On its approach to the Angle of the Town upon which it impinges, it passes between the Brick kilns to which I have before alluded and the enclosures attached to the Commissariat Department in which the Government Elephants and Camels are kept. This ground is much broken, being intersected by holes excavated for brick earth, which from the length of time during which material of this sort has been ~~made~~ used and carried away, assumes at the present day, the character of a series of Lakes rather than holes receiving as they do not only the rain that falls upon them but the drainage of a considerable area of land in their vicinity. Through one of the largest of these Lakes, the Canal Channel passes just before it reaches the Elephant lines not far from the North angle of which No 11 Bridge is situated.

Idea

In advance of this point the natural drainage of the Country takes a new direction. A tract of Country which lies on the right of the Canal over which there is a good deal of building besides a considerable surface consisting of either open Spaces belonging to the Cantonment, or cultivated land beyond it, the whole embracing an area of nearly two square miles, acts as a Catchment basin which is drained by two well defined Nullas meeting each other in the Town and

and proceeding after their confluence in a deep Channel which gradually becomes a formidable ravine. This nulla passes the Church and crossing the Course (Corso), for which there is a bridge adapted to it, proceeds onwards (receiving other tributaries) to the Jungel.

This Catchment basin is marked by numerous Tanks or ponds, all of which in that part where the Bazar is situated, are completely surrounded by huts and buildings, most offensive in every way, whilst those on the open plains although characterized by a comparative cleanliness, are from their want of well regulated drainage a nuisance. The principal ponds of the sort alluded to, are figured in the Map and it will be observed that the Canal in its course through the Bazar passes through two of them. On all this portion of the line, therefore, the drainage crosses the Canal alignement very nearly at right angles.

Proceeding onwards on the line which we have taken up for the Canal it appears that a ridge upon which the Musjid (Mosque) and Serai noted in the plan are situated lies upon the watershed of the Church nulla, and that the opposite side of the slope sheds its water in a ravine nearly parallel to this nulla, but with a direction corresponding with the Canal itself. Along this nulla in fact the Canal Channel is carried on.

the

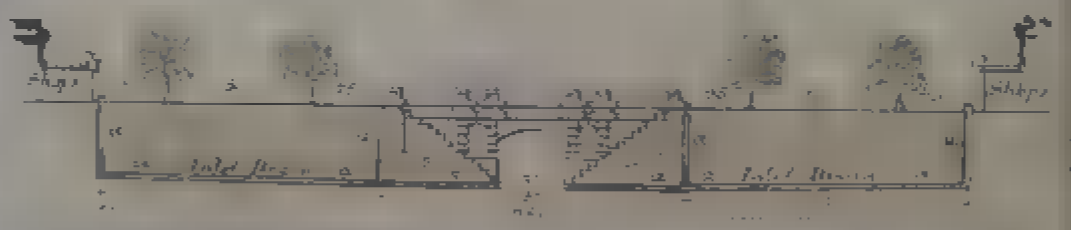
the lower part of its course, and in conformity with it joins the Ganges at the Gola Ghat.—

The line of Canal in its passage through the Cantonment of Cawnpoor comes in contact with 2 distinct basins of drain-age both of which will be per-fectly understood from the map.—

The depth of digging from the point A, or from bridge No 1 up to No 6 on the Course bridge, averaged about 12½ ft. On this line which extended over a length of 3700 feet, the flat-ness of the surface admitted of the works being carried on on one level. The large excava-tion, however, required for a Channel 12 feet in depth, with [illegible] side slopes adapted to the quality of soil with which we had to deal would have been [illegible] out of proportion to the means to which our finan-ces were limited; it was thus determined on levelling the whole line with brick retaining walls, by which we should econ-omize space by relieving the work from slopes.—

The design that was deter-mined on was shown in Diag. XXXVIII a copy of which is for conve-nience of reference introduced here.

Diag: CXXXI



The design in fact was an expansion

280 feet in width, bounded on each side by Bazaars or native [illegible], and having the Canal Channel passing down its centre. Bridges of brick communication were to be adapted to the different streets that had been intersected by the works; and the spaces on the right and left were to be ornamented by four single lines of mangoe trees forming avenues extending on each side of the Canal from [illegible] Bridge to the Ganges River.

My idea was that these avenues with the [illegible] and well laid metalled road or esplanade on which they were placed, would become the general promenade, and at any rate the camps and [illegible] of the [illegible] neighbourhood.

I have in the chapter above alluded to referred to this as well as to the other objects which I contemplated in this line of works; the works themselves however, are the subject of the present chapter.

From No 1 to [illegible] Bridge the ground being even, the works were laid out so that the Esplanades or upper levels should be parallel with the Canal bed i.e. on a slope of 12 Inches per mile. Between 1 & 2 [illegible] bridges [illegible] others were built, as on the plan shown in sheet XLIV of the Atlas.

These [illegible] bridges, therefore divided the whole length of the Channel into 5 separate bays, each of which had its retaining

walls

wall in the alignement of the bridge wing pillars, and its Channel fitted with either ghats (flights of steps) for the convenience of bathers, or with perpendicular revetments or Quays for that of merchandize. The design of these different works will be understood from the plans.

Parallel to the Canal Channel, and in lines one of which rests on the extreme Canal boundaries, and the other on the back of the retaining walls of the berm, are a series of drains or Bombas, dropping vertically into masonry channels, which are constructed at right angles to the Canal. These drains are built in positions suitable to the wants of the [illegible] around and it is supposed that they will give efficient drainage to all the Town, Bazar, and land [illegible] it. The principle on which these drop drains are arranged with reference to carrying off the water from the high levels to those of the Canal Channel is shewn in the above diagram a. a. a. a.

The dimensions of the different bridges and bays as mentioned above are as follows:–

A	No 1	Bridge	feet 33
		Bay	57.3
B	2	Bridge	33
		Bay	6.4
C	3	Bridge	33
		Bay	58.75
D	4	Bridge	55
		Bay	12.15
E	5	Bridge	33
		Bay	6.5
F	6	Bridge	33

Total length [illegible] A [illegible] to [illegible] of Bridge F total 381 feet

/

On the left of the Bay and corresponding with the lower branch of the Church Nulla, an outlet with 2 openings of six ft. wide each has been constructed for the purpose of giving relief on the occasion of heavy floods as well as of acting at a convenient spot as a regulator for the supply of water upon the heads of the locks.– This outlet is carried under the esplanade by masonry channels which pass off the water down the Church Nulla. Sluice gates for the purpose of regulating this Escape are arranged at its head; they are on the simple construction adopted elsewhere.–

The Bridge F No 6, which is built for the accommodation of the Course (Corso) road is ~~built on~~ a skew with an angle of 55½° conformable to that at which the road crosses the Canal.

Up to this point, the evenness of the surface of the ground admitted of the works being built, not only on an almost direct line, but with their upper and lower levels corresponding.– From the Course bridge, a new order of things commences, the ground falls off in considerable slopes and at a point 515½ feet from the downstream side of the bridge, the drop of the 1st Lock is situated.– Although the same system of parallel revetted lines for both the Channel and Esplanades is continued, the irregularity of the upper surface necessitated a deviation to the Esplanades,

de

so that whilst the Canal bed continues on its uniform slope of 1½ Inches per mile, the esplanade or surface of the Embankment is carried on in a succession of slopes corresponding with the depth at which the different Locks are situated. On this line, moreover, the direction to which we were limited forced upon us the necessity of continuing the curve, so that in standing on the No 6 Bridge we lose the perspective which a direct bearing upon the Ganges would have given us; an effect which would have been of material advantage to the look of the works.

From No 6 Bridge, the surface of the esplanade and its retaining wall slope downwards on an incline of 1¾ to 100 for a length of 267 feet at which point it meets the horizontal level upon which the lock buildings are constructed. The distance between the foot of the inclined plane and the upstream face of the Bridge which crosses the lock chambers is equal to 368½ feet, and it is proposed that this flat should be used as a landing place for goods by boats having reached the higher levels. In the immediate neighbourhood of No 6 Bridge, flights of steps are built for communication between the high levels and the berm, and close upon the walls of the lock chambers are side channels for the supply of Mills which are situated on the right and left, beyond the limit of the

the

~~the right and left beyond the limit~~ of the 220 feet boundary. The waste or Escape channels of these mills enter the Canal below the bridge and at a point free from the influence of lockage.

This Bridge which is called No 7 C corresponds with the [illegible] the main Cantonment roads, it is built at right angles to and over the Lock chambers, and has a roadway of 30 feet in width (vide Plate XLIV, Atlas) [a total width between the up and downstream faces being 35 feet]

At this place I may describe the locks, as although in the detail of fixing and working the gates, in the plan and arrangement for the regulating sluices, and in the general dimensions of the chambers, they correspond closely with those which have been built on the main Trunk and which I have fully described in a former chapter, there are some differences in the lining and general detail that are deserving of explanation.

In the first place I required an ascending and descending lines, so that boats might pass up from the Ganges at the same time that others passed down. I considered it to be a great advantage, that even supposing ~~that~~ the Ganges Canal was not available for navigation, the means for raising loaded boats from the low levels in which the River runs, to the higher where the Town and Cantonment are situated would be a great boon to the commercial

Community

community, and would be a very great advantage. Such arrangements might be made by properly economizing the water so that even in drought when Irrigation carried off the greater part of the supply, a sufficient Quantity of water would be available for purposes of the lock required and, although, after all, lifting boats by Common water Locks is but a clumsy arrangement, and in all cases a very slow one, it is a very great improvement upon the existing method of unloading boats on the lower levels, and carrying the Goods on Carts or mens shoulders to the higher.

Again not only is this needed for this purpose, but to give fuller means for regulating the supply at the head of the Locks by apparatus fixed in the Lock itself [illegible] it was desirable to design both Channels independent of the Chambers, and in such a compact form that they might be gained at the smallest possible outlay.

It will be seen, therefore that the Central wall separating the ascending and descending Lock Chambers, is provided on its whole length with a Channel 6 feet in width, fitted at its [illegible] with Regulating Apparatus. Into this Channel the low level Chamber Sluices with their circular drum regulators, discharge the surplus water, which passes off at the outlet at the lower end of the wall.

The drop at each of the Locks is 6 feet with a reservoir of 6 feet in depth at its foot, in front and at a distance of 7 feet from the drop a timber apron for the purposes elsewhere described separates the drop from the main body of the Chamber which is 112 feet long inclusive of the lower gates. The width of the chambers is 16 feet. The detail [illegible] and Collars is precisely the same as that carried into effect on the main [illegible].

[illegible] the [illegible] stream [illegible] No 7 G [illegible] Lock Bridge [illegible] a similar [illegible] to that last described [illegible] No 6 H bridge, [illegible] with [illegible] 12 [illegible] [illegible] 250 [illegible] [illegible] 1½' in 100 feet. [illegible] total distance between [illegible] stream [illegible] being 1343½ feet.

No 6 Bridge H passes the [illegible] Street of the Cantonment [illegible] the Canal, [illegible] width [illegible] between [illegible] of the [illegible] is 31 feet, and its total width between [illegible] is 33 feet. This [illegible] Street road has [illegible] by the [illegible] of the present bridge the [illegible] the road [illegible] depression [illegible] was [illegible] the great

the-

disfigurements of the main drain so that there a good deal of the work was necessary in order to improve it, before making the necessary effective drainage.

It was proposed to [illegible] Roads to the Crown [illegible] drain out of [illegible] by the [illegible] as well as [illegible] the [illegible] of the [illegible] with [illegible], [illegible] with a quantity of broken [illegible] ground, which required a great deal of additional [illegible], and much care and judgment [illegible] attention on the part of the Engineer or Executive [illegible] to dispose of the drainage [illegible] during the process of [illegible] and the [illegible] so that the water might be admitted in sufficient quantities to [illegible] the [illegible], and at the same time [illegible] gradual [illegible] the [illegible] itself should be [illegible]. This was [illegible] [illegible] the [illegible] season, the greater portion of the drainage water [illegible] the [illegible] being [illegible] as [illegible] in diagram CXXI.

[illegible] 401 [illegible]

From the down stream face of No 8 Bridge **H** to the head of the drop of the next Lock the distance is 852 feet; the Canal bed being continued on a slope of 12 inches per mile. At the point where this descent takes place, the fall is considerable, and it is disposed of by two Locks in succession each having a fall of 9 feet. The design of these works being similar to those before described needs no further illustration ~~[illegible]~~. At their tail end No 9 Bridge **I** is thrown across the Chambers in the same way as it is done in the cases before described; affording convenient cross communication to the gardens and houses in the neighborhood.

The plan of overcoming the depression of the country on this line is effected in the same way as was described in the approach to No 1 Lock. The Esplanade is carried on an inclined plane from the down stream face of No 8 bridge on a slope of 1 foot in 100 feet to a point 631 feet below it, from whence the esplanade continues horizontal up to the head of No 3 Lock from which point another inclined plane on a slope of 7½ in 100 feet delivers the esplanade on the [illegible] No [illegible] bridge which is thrown over the said crosses the [illegible] Lock chambers. The fall at the head of the Locks [illegible]

[illegible]

-cation or loading and unload-
-ing merchandize.

Between these two Bridges [illegible] we were in con-
-tact with the old ramparts, and on the down stream side of and close to the [illegible] extending for 153 feet, with its bottom 12·2 feet above the canal [illegible] had to be filled in and the foundations of the embankments had to be carried to a proportional depth; on the approach to the head of the Locks, a good deal of ground had to be cut away to bring the embankments on a uniform level. The nature of the ground in part was a [illegible] drains, wells and other [illegible] much care and [illegible] [illegible]

At the head of the Locks No 2 and No 3, arrangements [illegible] have been made for the [illegible] outlet heads, for [illegible] mills or machinery, should such be hereafter desired.

[illegible] continued [illegible] as it [illegible] as is fully detailed in the [illegible]

We are now rapidly descending to the edges of the water of the Ganges, at [illegible] [illegible] described as a precaution ~~[illegible]~~ in [illegible] the immediate vicinity (of the town) [illegible] water [illegible] as the [illegible] is com-
-paratively [illegible] be [illegible] the [illegible]

to the [illegible] series of descent by which the Canal works are gaining the lower levels. Thro' these grounds cutting to a considerable extent was required especially in advance of the works which I have just described.

From the Main Staircase of [illegible], the 13 flights rises [illegible] upwards, until they meet the horizontal lines which continue up to the [illegible] buildings. These steps have a rise of [illegible] 9' in height and the length of the flat or land is equal to 503¼ feet, measuring from the foot of the steps to the [illegible] front [illegible] of the [illegible]. On this line [illegible] locks are situated, each with [illegible] placed [illegible] to each other as [illegible] and 3, and [illegible] and design [illegible].

On this line there is [illegible] across the [illegible] Locks [illegible] the canal, which it will be observed by reference to Fig. 2nd of Plate XLIV Flows 13 [illegible] the [illegible] of [illegible] Lock.

Drawn [illegible] fig. 4 II Chapter II [illegible] the works of the [illegible] Terminal [illegible] described the Architectural features of the [illegible] on its [illegible] Face showing how I have attempted to plan these buildings, [illegible]

[illegible]

others which scattered along the edge of a richly wooded bank are so characteristic of River scenery as connected with towns and cities on the Ganges and Jumna. The Lock Chambers are flanked by semicircular Ghats or flights of steps, reached from the higher levels by stairs opening laterally from the higher levels of the Es-planade. These lateral stairs are broken by a landing place which gives the steps a direction to the front, and delivers them on the upper terrace of the semicir-cular Ghats. On the right and left of these steps and standing well above the terrace are pedes-tals for the reception of sculptures emblematical of the Ganges River. The sacred cow, which is one of the most often Hindoo conception in the way of sculpture, being a Cow in repose although with its head raised, is the emblem that is proposed for these pedestals, its face would be toward the stream.

On the flanks of each of the semicircular Ghats, are octagonal pavilions consisting of Domes supported on pillars. Each flank, therefore, of the Lock Chambers is ornamented by 2 pavilions with their intermediate flights of steps, those of approach to the pavilions in each case being flanked by the sculptured figures before alluded to.

The state of the Ganges River during high and low water will be understood from Fig. 2 in Plate XLIV of the Atlas. The extremes as shown in this

Sheet being 15 16 feet. During high floods, therefore, the lower or the 5 Lock would be entirely thrown out of use; this also would only require the use of the Gates for loaded boats on their drawing more than 13 inches; and in descending matter, the volume of water passing down the Canal would supposing it were 5 feet in depth, reach the high levels of the Ganges on a rapid which would render the use of the Gates and 5 Locks unnecessary.

On the upper levels to the works just described and on the flat below the Rog Bridge, houses for machinery might be erected, water power, however, at this point would vary with the rise and fall of the Ganges, and during the rainy months when the surface of the River is at its maximum, it would be either diminished or stopped altogether. Mills and other machinery, therefore, ought to be placed on the levels on and above which Rog Bridge is situated. On all that upper line, the back water from the Ganges River would have no influence.

From the above description with the plans before him, the reader will be able to comprehend the design of these works through their whole length viz. from the Rog Bridge where the continuous masonry works commence to their junction with the Ganges River. The total length is 7973 feet. 3602 feet of which has

its esplanades on a level parallel with that of the Canal bed, and the remainder which includes the whole line through which lockage is required, in two successive slopes nearly corresponding with the natural descent into the River.

As a general rule the surface soil to a depth of 6 to 10 feet was found to be of a very tenacious quality, below which it was more or less sandy, in some places consisting of sand. The foundation was laid in without any [illegible] from springs [illegible] water, or a work subsequently of simple construction, and no unusual [illegible] of walls. The whole of the locks have been built of brick masonry, generally of the 12" × 6" × 3" bricks burnt in the neighbouring kilns, although the small native brick has been largely used, not only from the [illegible] old buildings [illegible] but also from the [illegible] native kilns. Good and well burnt bricks in fact were taken without reference to their size, although the larger class was preferred, and was more generally brought into use.

2nd and directed a short [illegible] attention to the design for the foundations of the River front which, as coming in contact with a lighter soil, and being directly in connection with the Jumna River, required great care and attention. On the face of this plan [illegible] work [illegible] designed to the [illegible]

drawings of the works, will sufficiently explain the nature of the operations with which we had to deal. The superstructure it will be observed is founded on a series of blocks, undersunk in the way that has been elsewhere described. These blocks are carried to a depth of 12 feet, varying, however, with the nature of the soil that was met with in the course of undersinking. For protecting the whole work and forming the same a protective apron of piles and heavy material [has been given] similar to that which has been adopted wherever masonry work is in contact with a stream or current, ~~has been~~ ~~a~~ as shown in Fig. 1 and 5 Plate XLIV of the Atlas.

The rate at which the Brick Masonry was executed on this line of works averaged per 100 Cubic feet Co's Rs 11.11.1 the extremes being

Rs 19.10.8 for Arch work
" 11.1.10 for other kinds

The difference depended on the species of work that was executed.

From No 1 to No 4 bridge on the upper line, with a few [illegible] No. [illegible] was done under the management of Lieut. C.W. Hutchinson who in the first instance had charge of the works. The cement which was used at this time consisted of about equal parts of Kunkur Lime and Bujree [illegible] the rate of masonry being per 100 Cubic feet Rs 11.9.10. Lieut. Hodgson who succeeded [illegible] by having [illegible] the works, [illegible] putting [illegible] the [illegible] line [illegible] contractors, [illegible] an [illegible] which [illegible] to superior masonry. Lieut. Hodgson's [illegible] cement were as follows:

3/7th Kunkur Lime
1/7th Soorkee
3/7th Bujree —

and the rate per 100 cubic feet of masonry was Co's Rupees 11.11.6 —

The rate for [illegible] the bricks is shown below: the

— — the work, however was in progress at the period of my leaving India, and the Rate, therefore, which I have given is consequently imperfect in so far that it does not include the general averages of contingent expenses, which can only be made up on the completion of the work.

Cost of undersinking masonry Blocks at the Cawnpore Terminus Cost 7. 2. 0 per running foot. —

Section II. Terminal Works on the Etawah Line.

[illegible] of these works had been commenced at the period of my departure [illegible] 1853. and as I have [illegible] in a former chapter, I would recommend their postponement until a future date, when the supply of water and its effects upon the Cawnpore Terminus are better understood than they are at present. There is no use in hurrying to completion works which cannot in all probability be required for many years to come. I would, therefore, collect all the imperishable materials e.g. Kunkur and bricks necessary to carry on the buildings with vigor, when Lockage into the Jumna was desired, but as the progress of the works now going on

on, on the Etawah line will not for a period of 2 years be advanced to the point where the terminal works are to be built; there is plenty of time both for consideration as to the period of their construction, as well as to their design. Of the latter, therefore, I shall content myself with giving the general views I hold on the subject, leaving the detail to my successor, who will be better able than I am to determine a plan for buildings appropriate to the desired object.—

There are two points on which the Cawnpore and Etawah Termini differ very materially, and both of them are of great importance in any design that is projected. 1st. The Cawnpore Terminus is in the midst of a town, through which the Canal channel passes on a length of 7973 feet, before it reaches the river. 2nd. The slope into the Ganges at Cawnpore is comparatively abrupt, the locks being at no great distance from each other, and all of them in a compact and regular series. The Etawah Terminus into the Jumna on the contrary, is in an open country separated altogether from towns or villages, and the high bank or commencement of the descent from the high to the low levels is situated at a distance of 1¼ miles from the Jumna [illegible] on the Bundelkhund or opposite side of the valley, leaving a long tract of intermediate low ground

between.

between the 1st Descent down which lockage will be required, and that by which access will be gained to the River itself. — Here therefore will be a long straggling line of works instead of a compact series of buildings as is the case on the Ganges; and here, also a less expensive design will be more appropriate. It must nevertheless be kept in mind that, if the supply of water in the Canal is sufficient to afford water for navigation as well as for Irrigation: and if there is sufficient water in the Canal to keep a constantly running supply upon the locks, these buildings will inevitably become the nucleus of a Town, and the seat of a manufacturing population, based upon the water power which is available on the high levels upon which these works are situated. Although therefore there may be no necessity for going into heavy expenses in Ghats, Mills, &c &c, in the first instance, we ought to hold these things in contemplation and to anticipate a plan where if wanted they might be built in conformity with a comprehensive design of which the present works ought to be the nucleus. —

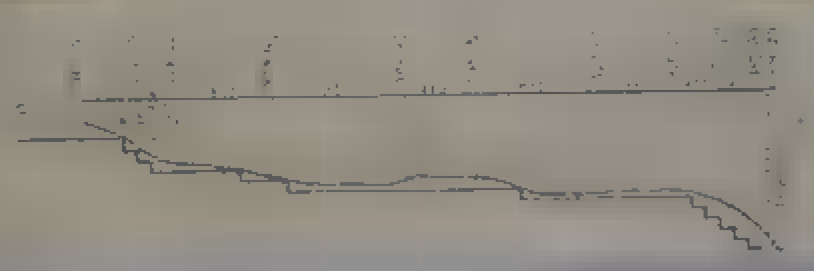
Under this view of the Question therefore, I would retain the plan of the ascending and descending series, or the double line of Channels as has been built at Cawnpore; I would also adopt the rather

of

of Waste and Escape Channels been practised, but I would limit the extent of Revetments, and be satisfied ~~as much as possible~~ for the present with Earthen Slopes, ~~and at~~ thereby ~~through~~ leaving full scope for ~~all those~~ improvements ~~hereafter~~, afterwards ~~[illegible] in the first instance~~ ~~[illegible] to any of them.~~

My Plan would be as follows, working upon the section of the Country as shown in the following Diagram.

Diag: CXXXII.



The above Diagram exhibits in section the slope of Country connected with the Descent in approaching the Jumna River. There will be four steps separated by reaches varying from 600 to 2000 feet in length; the design of the upper 3 steps together with that of the Terminal Escape into the River will be understood from Plan in the Atlas which represents ~~the~~ Detail the whole of this work ~~the intermediate~~

for passing these steps be understood from the [illegible] of the Atlas which represents in detail the terminal rest of Locks which deliver the Canal water into the Jumna River.

Section III. Termini of the Branches

A. Futtigurh Branch. This is a work which is altogether prospective; it has been fully explained in part II Chapter III see page

At present the Branch is strictly for Irrigation and it terminates at the 160th mile of its course, in an escape which throws the tail water into a line of natural drainage. The distance from the terminating point above noted to the Ganges River at Futtigurh is 21 miles and as the total fall may be considered as equal to 70 feet, a series of lockage as I have proposed, eight or drops of 8 feet each with an intermediate slope of 5½ inches per mile, so as to provide a moderate current to the channel, would connect this branch with the Town of Futtigurh as well as with the Ganges River, which runs immediately below it. I have gone fully into this subject however in the chapter before referred to.

B and C. The Boolundshuhur and Koel Branches, the former after passing through 80 miles of Country and the latter through 56, form a junction at a point not far from the Town of Hatrass. From thence they proceed onwards in one united stream under the name of the "Hatrass line of Irrigation" through the Country lying between the Seyngoor and the Jumna Rivers. This line terminates in the Ravines on the Seyngoor River, or it may be carried over these Ravines and form a junction with the Etawah

Terminal

[illegible] on its approach to the Jumna. It is supposed, however, that at such extreme points excepting during the rains, there will be no water sufficient to render permanent works necessary a point which experience only can decide.

I have when describing the Rohundshuhur branch alluded to the possibility of a navigable line being taken from that Branch to the Jumna passing by the town of Belaspoor. This line would join the Jumna immediately below the confluence of the Hindun river, and might be convenient by opening out a line of traffic from a Country richly cultivated to a River which although not capable of carrying heavy craft during the dry months of the year, holds sufficient water for the easy passage of such boats as would pass down the Canal: it would in fact connect the Boluntshuhur and the districts in its immediate neighborhood with Delhi, Agra and other Towns lying on the banks of the Jumna.

Hall

CHAPTER , IX .

Solani Aqueduct

The works on the Solani River which ~~[illegible] the head of~~ are grouped [in] this chapter are divided into three distinct [illegible]

I. Earthen ~~Aqueduct~~ Portion studded with Drainage works ~~[illegible]~~ for the passage of [illegible] the [illegible]

II. Masonry ~~Aqueduct for~~ Portion for the passage of ~~[illegible]~~ the [illegible] torrent.

III. Works and Improvements on the Solani River itself in connection with the Aqueduct.

I have in the [illegible] paragraphs explained the position held by the Solani Valley with reference to the [illegible] of that portion of the [illegible] [illegible] with which the [illegible] works are connected. It is [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]; the [illegible] [illegible] [illegible] [illegible] with these works [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The Area of the [illegible] [illegible] above the works [illegible] [illegible] 216 square miles, the length [illegible] estimated at 27 and its average breadth at 8 miles.

of this area 50 square miles lie in the Siwalik Hills, the remainder on rapid but gradually decreasing slopes till it reaches the village Bagwali tracks where the fall in the bed of the River is 5·0 feet per mile.

The topographical character of this Basin is exactly the same as that of the Basins of the ~~[illegible]~~ ~~[illegible] before described as attendant upon~~ other mountain streams connection with the Siwaliks already described. In the hills themselves the tributaries and water channels that pour their supplies into the main branches are distributed on courses so marvellously tortuous, and are so curiously entangled with ravines, that without ascending the top of one of the high peaks which are scattered along the ridges, it is hardly possible to appreciate the nature of the drainage, or to estimate the amount of area connected with these hills ~~[illegible]~~. The aspect of the Siwaliks as viewed from an elevated point, is that of an extensive plateau, broken up by an intricate ramification of fissures & ravines, the continuity of any single line being to the eye untraceable, and the inextricable confusion that appears to exist. The position of watershed can under such circumstances hardly be defined, and that above given which is taken from the Revenue maps must only be considered

as

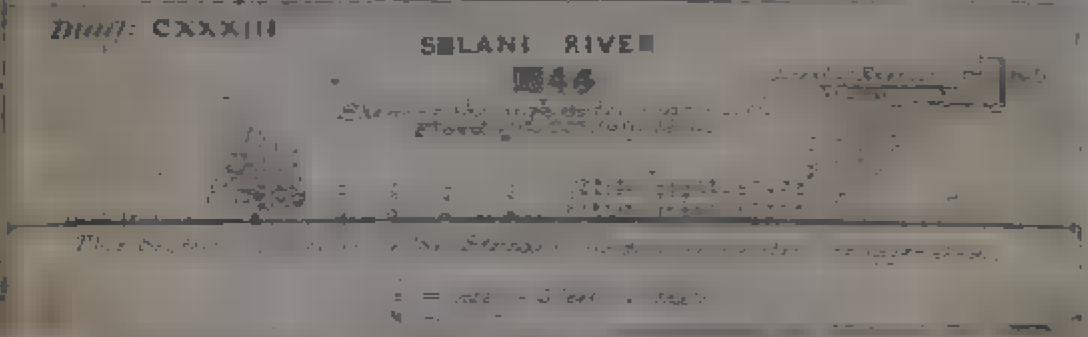
as the best approximation. The Solani valley lies on the extreme west, and ~~[illegible]~~ skirts the Range or high land of the Doab and which course to the Ganges. Its heads are on the watershed which divides the basin of the Jumna from that of the Ganges. The water that is shed on the western side comes in contact with the Eastern Jumna Canal works, as connected with the Mushkura; that on the Eastern flows towards the Solani Aqueduct.

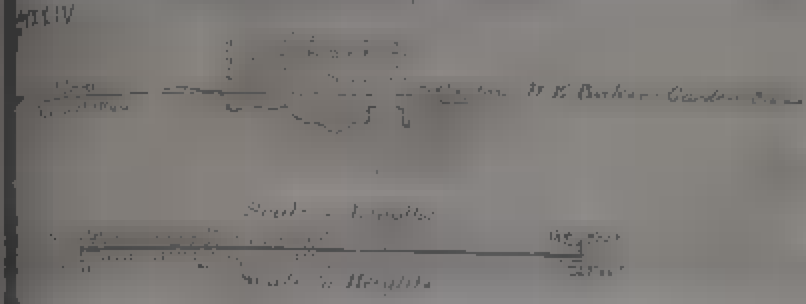
The Mushkura, as I have formerly mentioned, has great advantages in its elongated position with regard to the general drainage of the high land over which it passes. These advantages have been greatly developed ~~[illegible]~~, and used largely in directing the drainage on lines leading away from the canal works, by which the River itself, in its coming in contact with the Canal at Nulsera, is reduced to manageable proportions.

The Solani, on the contrary, which has a hill front equal to 12 miles, plunges at once into lowland, and one of its main branches which debouches from the well known Pass called the Khori or Lal Durwaza, (through which is a road from the plains to Mussoorie and Landour) forms its junction with the Main Stream that proceeds onwards under the name of the Solani, just below the Town of Kheeri and the high

high road from Saharunpoor to the Hills. At this point the high land which forms the Eastern border and along the western foot of which the Solani River runs, is 18 feet higher than the bed of the River; a command which is increased on its arrival at Roorkee and at the site of the Aqueduct to 24 feet. There appears therefore to be no bar to any diminution of the volume of the Solani River by throwing it upon other lines, as has been done in the case of the Mushkurra. The [illegible] that have [illegible] which lie to the West of Roorkee and Saharunpoor, appear to be the only available hollows for such a purpose, and their relative levels are opposed to it. It has therefore been considered as a matter not to be disputed that the Solani River has to be dealt with in its integrity, and that as in the case of the Rutmoo and Puttri torrents, we have no other resource than to meet each other by mutual accommodation. Without loading my pages with registers of floods, the following diagrams of the two of the highest on record since the year 1846, will give a tolerable idea of the extent of the Plain and of the amount of inundation dependent upon it during the rains.

Diag: CXXXIII





		Area of Section	Assumed mean velocity	Discharge per Second	Waterway of Aqueduct	Co-efficient of Efflux
Holui flood	1846	[illegible]	6·0	[illegible]	[illegible]	[illegible]
"	18[illegible]	[illegible]	6·8	[illegible]	[illegible]	[illegible]

Both these floods occurred prin[illegible] cipally to the [illegible] of the aqueduct works, [illegible] obstruction [illegible] had been placed in the way of the water. The value of the calculation may be estimated by the [illegible] -ments applied to the [illegible] [illegible]. The section of [illegible] was taken somewhat obliquely to the course of the River [illegible] [illegible] raised the calculated [illegible] [illegible] [illegible] the line [illegible]

The Valley [illegible] [illegible] [illegible] [illegible] the hills [illegible] up to [illegible] below the [illegible] of [illegible] is [illegible] [illegible] of that [illegible] [illegible] to the South [illegible] part of the [illegible], composed [illegible] a great [illegible] of [illegible] Across [illegible] [illegible] [illegible] dotted [illegible] with [illegible] gigantic trees, which, however, [illegible] [illegible]. The [illegible] the immediate neighbourhood of the hills is [illegible] [illegible] by boulders obtained from the degradation of the superstrata [illegible] [illegible] which consists of shingle beds; [illegible] the lowest it is a [illegible] sand, much

Under

intersected by lines of drainage the Budarka, & through course before its branches reach Kirani.

Below this junction, or below the confluence of the different branches which are connected with the [illegible], the River runs in a straggling course between the high isolated mound which separates it from the [illegible], and the cultivated land on the right; at some points it shows a well defined section through clay of a very tenacious quality, but others, generally speaking, it wanders about in a tortuous course through the lowland in a [illegible] which during geological periods corresponding to ours its bed is [illegible] salty sand, although in the process where the River runs in a confined channel the banks and bed are of clay. A very good section of the latter description will be found at a distance of 800 feet from the upstream side of the Aqueduct, where the River during its highest floods appears to pass through a well defined channel without lateral inundation of any sort. At the site of the works the course of the River was tortuous, with a sandy bed depressed about 4 feet below the surface of the valley, which on its whole extent below Kirani is more or less cultivated with wheat and other cold weather crops.—

It will be understood that

that the high land bordering
on the Solano valley to the [illegible]
[illegible] or Berkeley throws a
considerable quantity of drain-
-age water into the valley; this
is effected on the right by the
numerous offshoots, some of
[illegible] extending [illegible] into the
country, and connected with
land of very undulating char-
-acter. On the left or [illegible] the
isolated high land which I
have called the [illegible] hollow
ridge, the same species of drain-
-age takes place [illegible]
[illegible] is [illegible]
features [illegible] and
[illegible] drainage [illegible]
[illegible] the [illegible]
[illegible] the [illegible]
the [illegible]
[illegible] of the [illegible]
[illegible] that [illegible]
to the [illegible]
the [illegible] above [illegible] the
Solano valley, [illegible]
[illegible] called the [illegible]
[illegible] to the east of that
[illegible] the [illegible]
at a [illegible] about 7200 feet
[illegible] the [illegible]. I may
[illegible] that in estimating the
[illegible] of the [illegible]
[illegible] the [illegible]
[illegible] on the [illegible]
on the right, and the [illegible]
[illegible] the [illegible] of the
[illegible] ridge [illegible]
[illegible] the left of the Solano
valley, as ground which [illegible]
its water into the Solano River.

A [illegible] which
is an attendant feature [illegible]
the

these Khadir [illegible] when are
[illegible] by high banks, left
the mistake of [illegible] parallel
to and close under the banks
the [illegible] is here as elsewhere,
[illegible] then
must [illegible]
[illegible]
[illegible]
[illegible] the right [illegible]
[illegible] at the
[illegible]

[illegible] to
the [illegible], to which the [illegible]
of the [illegible]
[illegible]
[illegible]
[illegible]
[illegible] through the [illegible]
[illegible]
1213965, [illegible], the
[illegible]
[illegible]
[illegible]
[illegible] situation of the
[illegible] of the
[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible] Plate LXIV
[illegible] alignement touches
the vallen first [illegible] the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] high [illegible]

Shahan

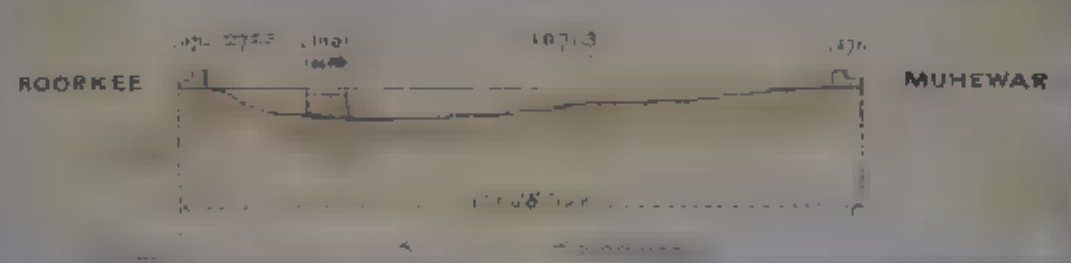
417. ΣΣ [illegible]
Part iii. Ch ix.

of [illegible] equal to 12[illegible] feet or a little more than 1½ inches [illegible] difference [illegible] the river bed [illegible] and that [illegible] the height of the [illegible].

The [illegible] consists of a [illegible] with a [illegible] stone [illegible] of [illegible] feet [illegible] [illegible] to the [illegible] of [illegible] in [illegible] [illegible] [illegible] a [illegible] [illegible] [illegible] a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] about the valley, and the [illegible] [illegible] [illegible] made with great care and well Consolidated.

The Longitudinal dimensions of the works on this River will be understood from the following Diagram.

Diag: CXXXV



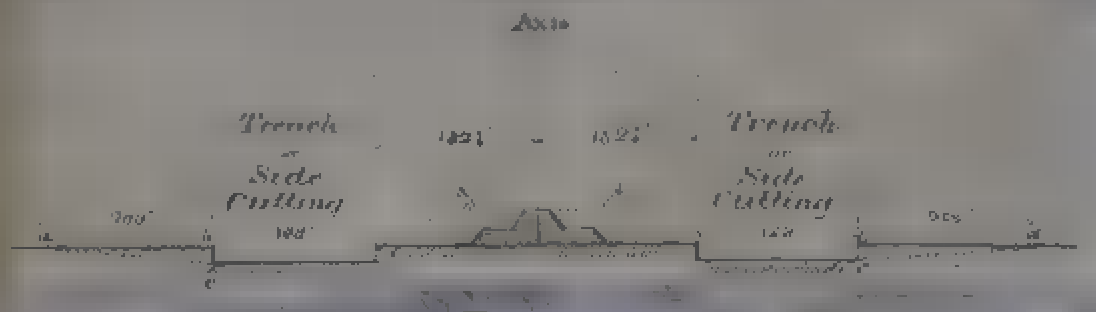
With these [illegible] [illegible] which [illegible] the general character of the [illegible], [illegible] the nature of the [illegible] [illegible]

been designed to ~~[illegible]~~ effect its pres-
-[illegible] [illegible] take up the detail
description, commencing with

Section I. Earthen Aqueduct ~~[illegible]~~ with masonry Revetments and ~~[illegible]~~ Terminal works &c.

This was the first portion of the Aqueduct works which was undertaken. The commencement was made in the cold weather of 1845/46 on the left bank of [illegible], and in [illegible] ground adjoining it and [illegible]. The work at this place consisted of excavating trenches on the right and left of the aqueduct line, and throwing the earth on the [illegible] so as to form [illegible] the raised [illegible] bank, [illegible] was to constitute the [illegible] of the canal in that portion situated between the [illegible]. The manner [illegible] which this work was executed was as follows.

Diagram CXXXVI



The trenches were 188 feet in width and carried to a depth of 5¼ feet the earth being placed in contact with the axis line above them, and in such a manner that it should not interfere with the building of the revetments, the [illegible] was [illegible] until the beginning of [illegible]. The earth obtained by the

means above described, although by no means inconsiderable in amount, was small when compared with that required. It provided however a good foundation upon which superstructure might afterwards be raised, the earth itself as taken from the surface was tolerably good, and in 1843, on my inspecting the works, I found the whole in a very satisfactory state of consolidation.

At the same time that the work above explained was in progress, the Canal Channel at Roorkee was going on, then a commencement was made on the edge of the high land, and the earth was carried out into the valley, the embankment moving from the high to a lower land on a continuous line of planks, the distance to which the earth was carried by these means, varied from 2 to 300 yards, and the labourers were paid from [illegible] according as it might pay by Rupees. Major Baker, who at the period that Cautley was absent was directing the operations of the works, in writing to the Military Board on the 24th August 1846 observes, that "the work above alluded to may be considered to have been executed under favorable circumstances and of [illegible] the rate of carriage varied from 3 to 5 Rupees per 4000 cubic feet, increasing with the distance to which the earth was conveyed."

urged, taken in pointing out the necessity for laying rails and waggons on the northern side of the Aqueduct, that a railway was a desideratum, showing that the whole of the earth beyond that already excavated in the side cuttings, must be brought from the Canal Channel excavation or the Solani [illegible] ridge, recommended that no delay should be employed for the despatch from England of the Contractor's request for a certain number of waggons, and that no time should be lost in the arrangements which had been previously proposed of obtaining from England three [illegible] artificers and men practically acquainted with Railway works. Already however, representations had been made for supplying the works with means of transporting earth from the distant cuttings. In the meantime, however, the progress of the works was delayed by a variety of circumstances which have been detailed in the first part of this report, and although nothing was carried on with vigour until very shortly before my return to India, I found on my arrival at Roorkee, a considerable number of waggons ready for use, with much preparatory information on the economical practice, and construction of Trams or Railroads as adapted for the particular duties for which we required them. Tramroads and waggons were construc-

Most

tively easy, and confined it may be said to working out the design, and carrying out such improvements as experience shewed to be necessary. —

Wilshire

On my returning to Roorkee and relieving Major Baker from the Directorship, the state of the works may be thus described. The bank[illegible] on the left or north of the Aqueduct was very nearly completed, and the earth was placed in position as shewn in Diagram xxxvi, a temporary or Stage Bridge had been thrown over the Nullah or line of drainage which I have described as skirting the valley on the Mahewur side, and which was intersected by the Aqueduct embankments, the object of this Bridge being to afford a passage or means of communication on the level of the valley, for Carts and Labourers, and on the higher levels for the Ballast waggons when carrying earth, the Bridge was situated on the axis of the Aqueduct as figured in the above Diagram.

On the right or Roorkee bank of the Solani a portion of the Side Revetments had been completed on a line of 101 feet, and a considerable portion of foundations and Arching had been done and was in progress in the vicinity of the completed portion; Earth had also been excavated, and carried as I have above described in wheelbarrows to the space between the Revetment walls. — Earth Yule who

at that period was Executive Engineer in charge of the works at Roorkee was also engaged in laying out the alignment of the Side Revetments between Roorkee and Muhewar; a work requiring great skill and careful observation, the direct line upon which the walls were to be carried being upwards of 2½ miles in length.

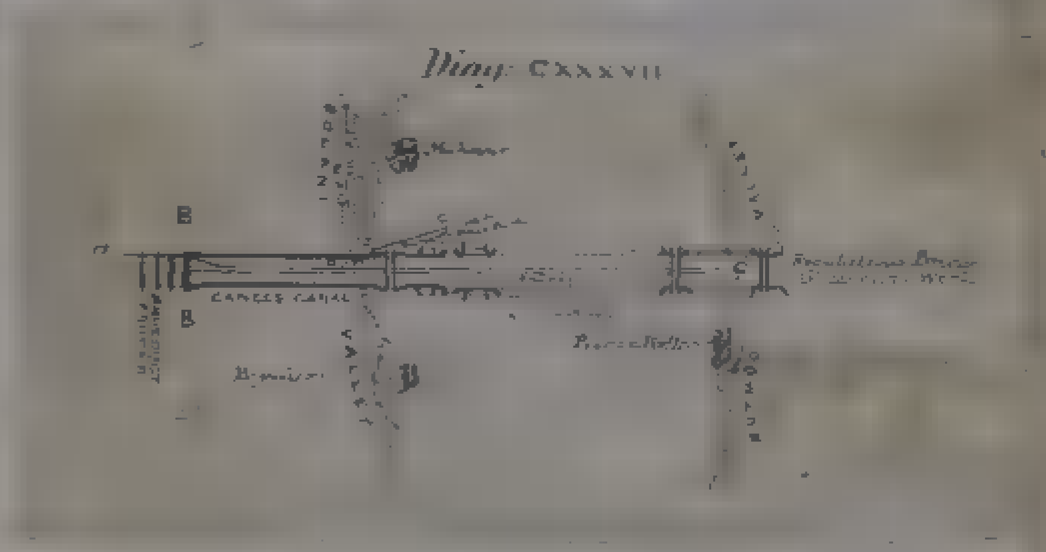
Captain Goodwyn who relieved Lieut. Yule on the 15th April, 1848, and Mr. Fenn who a short time previously to my return in January had been appointed to the Material Department, commenced at this period to organize a system of railways connected with the Brick Manufactories which had been established at Roorkee and Muhewar, that is to say at each end of the Aqueduct. The rail ways were necessarily a main feature in the earthen Aqueduct, as it was through them that the embankments would be formed. The first part of our operations, therefore, consisted in laying out the Brick fields in a uniform shape, with lines of rail running parallel and close to the kilns; these formed branches or 2nd Class lines, which were connected with the 1st Class, laid along the axis of the main canal. The former were single, the latter double lines of rail way. The branches were confined chiefly to the carriage of Bricks or material from the manufactories.

m[illegible] was the system [illegible] earth from the [illegible] to the [illegible] embankments which in viaduct [illegible] pattern was pushed forward into the valley, the railways being extended at their terminus in proportion as the work on the excavation and the embankment advanced in progress.

On the 2[illegible] or Malbourn side the direction of the slope of the Railways corresponded with that of the Canal and the natural flow of the water. A commencement to the railway therefore was made at a point near Malbourn. The line was launched on a slope of 1:3 per mile vertically in the Canal Channel and earth excavated from the Gerom Hill ridge was pushed out and the line progressively advanced until it reached the Island Level, at the point where the earthwork terminated in the masonry aqueduct. The gradient of the rail was 2 inches in excess of that of the line of the Canal, and consequently obtained at its extreme terminus a depression below that of the true head level. With this main Vertical line two branches were connected, one leading to [illegible] and limestone houses which were situated on the high ground, the other to the great brick manufactories under the Malbourn village and on the slope of the bank leading into the valley. The former 2050 feet in length was obtained by

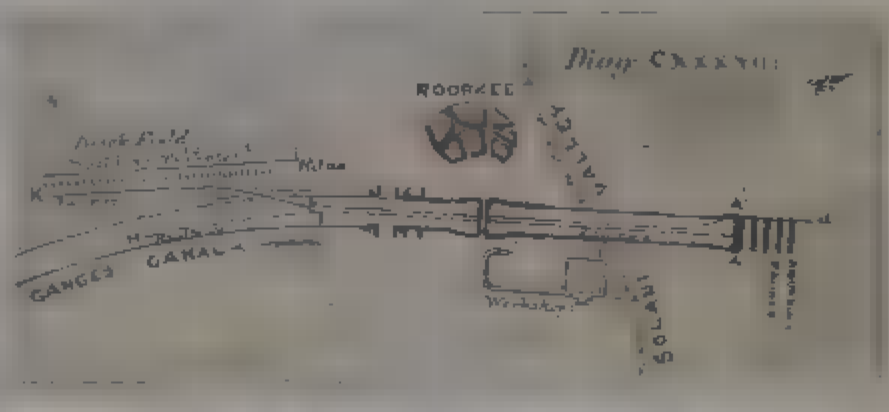
some moderately deep cutting, and was brought upon the main line by a curve of 300 feet radius on a gradient of 1 foot in 133 feet. The other was a steam track, as it had to be carried from the canal bed on rather a high level, over some very low ground lying on the outside of the embankments. Over this piece of low ground a temporary bridge was constructed, and the railway which was carried round on rather a sharp curve was [illegible] forward on an embankment raised commencing at 20 feet from the ground, and [illegible] rather to end at a distance of 100 feet from the line of Bank [illegible]. By this arrangement, although we had some difficulty in trading the wagons, we avoided the greater difficulty of a sharp incline, and [illegible] elevated line was so [illegible] to [illegible] passages [illegible] the [illegible] and [illegible] the rail at [illegible] distances above the [illegible]. From the sharpness of the curve at the point where the railroad crossed the [illegible] bridge, it was found necessary to raise the rails on the curve on outer side 3 inches above those of the inner. The length of this curve was 500 feet on a gradient of 1 in 50.

The direction of the railroads on the [illegible] side [illegible] shown from the following diagram. [illegible]



References	Distance
BC Main line extending from Left Abutment of the Aqueduct [illegible] Ratmau River to the Ratmau Valley	20853
DE Branch line to Lower Brick [illegible]	[illegible]
FG — Do. — Upper — Do.	[illegible]
a [illegible] line [illegible] Aqueduct Cut	1120

On the right or Roorkee side, after completing the facing and foundations of the Bridge, a similar line of rails [illegible] towards the valley. [illegible] of the [illegible] to that of the Canal [illegible] the [illegible] of the wells of the Bridge was raised [illegible] that the road [illegible] contact with the masonry [illegible] at the point where the [illegible] construction [illegible] particular point. [illegible] described by a diagram representing the different lines [illegible] with the Roorkee side during the progress of the works.



AH. Main line for Carriage of Earth	6355
KA'a. Branch line for the Carriage of Materials extending across Cut Waters of Aqueduct and meeting the Mohsum [illegible] Material line — distance from K to A'	5567 / 6700
XL	1350
LA'	3057
KL Brick field Branch	1300

The gradient of the [illegible] line on K A'a North of the Toorkee bridge was 1 in 208, South 1 in 200. That of the Excavated line H A was 1.25 feet per mile. –

The above although somewhat anticipating events when describing our early operations, will show how the railroads gradually got into proper form, the earth [illegible] line A H which [illegible] one uniform gradient so as to deliver the earth on the highest levels required for the [illegible] flood during our [illegible] progress [illegible] a very elevated position, whereas its parallel line A L [illegible] was specifically designed for the carriage of bricks [illegible] the [illegible] to the works was depressed so that at the point A' it touched the levels of the [illegible] water levels of the Aqueduct proper, [illegible] which it was carried [illegible] across the [illegible], and [illegible] a branch [illegible] the main trunk line on the [illegible] side of the [illegible] [illegible]. [illegible] [illegible] progress [illegible] of the aqueduct, and [illegible] [illegible] [illegible] and [illegible] became [illegible], a [illegible] that was more closely,

[illegible] on the completion of the [illegible] of the aqueduct proper [illegible] in the Main Trunk was carried across, forming a line [illegible] from Peeran Kui [illegible] [illegible].

The first [illegible] that was laid down consisted of bars [illegible] varying from [illegible]

inches in thickness screwed upon longitudinal sleepers, which was held in position by cross bars or transoms. This [illegible], with certain modifications and improvements in ballasting, quality of wood used, and method of fixing the bar upon the sleeper, was then used very successfully throughout the whole of the operations. They were subject to a good deal of wear, and were more difficult to place in position, than the English rail which was introduced in 1850, but they did their duty efficiently, had the merit of cheapness, and of being easily replaced by purchase from the neighbouring markets. In 1851 however, 25000 running feet of light rail bars which had been tested in England by [illegible] Walker, arrived at the works; they were of the variety designated bridge rails weighing 16 lbs to the yard, and the method by which they were fixed on the woodwork was much the same as that adopted in the first place, that is to say on longitudinal sleepers with cross bars at this period however, it was found it necessary to give additional thickness and increased weight to the sleepers [illegible] woodwork in general, and the ballasting was made of a better and more expensive species of material; the superiority of the rail over the bar was sufficiently recognized by me [illegible] of a double [illegible]

ed as that so prepared, giving us a total length of 6000 running feet, which with the line road, supplied us with all that was required both for the works at Gorham and Durance.

As the cost of the earth work connected with these Gaol roads naturally fell into the cost of embankments and was included in their expenses, it is difficult to give a precise value of the actual cost per running ft. of the different species of roads [illegible] upon these works. Of both the two [illegible] Railway double [illegible] feet then has been taken the cost of [illegible] timber with all the necessary apparatus for laying, including any [illegible] up to the period when the wagons were placed upon them was as follows:

[illegible] [illegible] } 3 [illegible] 1397 [illegible] 12.3
[illegible] do do [illegible] 1360 [illegible] 19.2

The work at each place was carried ~~[illegible]~~ under separate Superintendence, and the accounts as rendered to the Resident Engineer of the works, were quite independent of each other; the returns are therefore [illegible] so closely that they may be looked upon as fair rates of these species of railway. [illegible] it is distinctly to be understood that as far as the earth work is concerned, the above rates do not include the consolidation of the earth; the excavation, [illegible] or the carrying and other [illegible] work, as well as the Ballasting, being charged to the

Embankments, of which it [illegible] a compressed [illegible]. The above rates appear to us reduced in a great measure by the cost of single railway at Roorkee where there was no embanking, but where the sleepers were laid on the earth with little or no artificial ballasting further than was required to maintain the woodwork in position and to keep the rails steady. A mile of single rail laid down under the above circumstances cost Rs Rupees 8809. 9. 4; the work was done for wages which were dear, with the work of the working day passing backwards and forwards loaded with bricks, and although already inadequate to [illegible] a [illegible] track was quite sufficient for the purposes for which we wanted it.

Lawton

The cost of rails and where English rail was used [illegible] very little from that above described, with exception to the cost of the iron. The iron of the flat bar as fabricated in the markets was delivered at Roorkee at a cost varying from Rs 1700 to Rs 2100 per mile of single line, whereas the English rail, without [illegible] delivered at Roorkee stood us in Rs 2575 for an amount equal in extent to the above distance.—

The wear upon the vehicles and wagons was greater in the case of the flat bar than on the English rail, the surface for friction of the former being not only considerably greater, but [illegible]

more uneven. I can compare the difference of motion in travelling over lines made of flat bar iron and the bridge rails which have been used on these works to nothing better than that of unmetalled and metalled roads; comparatively speaking, they bear the same relation to each other; the wheel in the one case running awkwardly and with constant jolts, whilst in the latter an engine train, it passes on evenly and steadily.

Plans and sections of the different railroads with the wood and iron work connected with them will be found in plate XXVII of the Atlas.

Previous to my reaching Russia a number of small wagons had been made up with side doors and without tilting apparatus, these gave us the early means of commencing our earth carrying operations. I had, however, brought with me from England, tracings of what I thought to be the ~~xxxt~~ wagon best adapted to our works with the iron work of one wagon complete, a wagon made on this plan was immediately placed upon the work, its tilt was to the rear, similar to those which during my residence in England I had seen universally employed on railroads; and which was convenient for throwing the earth forward in pushing an embankment across a valley. This was

into

tilt however did not appear to be applicable in our case, the embankments in England are made little more than the width of the sleepers on which the rails are laid, the rear tilt therefore throws the earth in the position in which the Railway Engineer requires it. In the [illegible] weeks after the line of rail-road was completed, the rear tilt became useless as we required a wagon that would empty the earth on the right and left of the line, from whence it could be spread out on an extended surface, where the form of the [illegible] rendered indispensable. The rear was therefore changed into a side tilt wagon, upon which plan the whole of our carriages was ultimately made up. I have in plate XXVII of the Atlas given drawings of all the wagons that have been used

Sheet 20 Figs 1 and 3. in that which was made first of all is cheap and as far as first cost went the most economical; its want of tilt and the small quantity of earth that it carried weighed strongly against its further adoption, this species of cart, therefore, was discontinued after those which had been originally made up were worn out. The only modification that the cart in question required was the prolongation of the side coverings to a point beyond the wheels (vide figs 2 and 4 Sheet 20) so that in unloading the cart the earth might not interfere with the wheels.

rails. Before this alteration was
made the earth on the opening
of the side door fell upon the
rail directly between the wheels,
thereby preventing the movement
of the wagon and causing in-
terruption to the passage.

The cost of one of these
wagons including the wheels
and axles which were received
from Calcutta was Rs 286..9..5

Plate XXVII Fig 21 is the Ballast
wagon the plan of which I
brought from England, as as
I have before said a reasonable
and in other respects as well
as this, is *similar* to those of
English railways. For the reasons
above given only two on this plan
were made up though they
did very well but as I have been
before [illegible] they were not ~~[illegible]~~ well
adapted to the work. The cost of
each was Rs 438..1..3

Plate XXVII [illegible] is the standard
plan upon which all the
wagons in general use have
been made, it has a side and
tail as now though put together
and carries a load equal to
50 cubic feet. Of these 450 have
been employed either on the
works at Roorkee, or those
on the [illegible] at
[illegible]. The cost of each
averaged Rs 358..0..4

Having explained these
[illegible] the [illegible] and design
upon which the embankments
[illegible] made and having
[illegible] the [illegible] at our
disposal [illegible] the
[illegible]

[illegible] of the [illegible] Aqueduct
[illegible] with a detail
of progress. [illegible]
[illegible] to the completion of the
work [illegible] 20 [illegible]
[illegible]
[illegible]
[illegible]
The [illegible] the track
of the [illegible] of progress
of railroad at the [illegible]
[illegible] will be understood by
[illegible] CXXXVI [illegible]
[illegible]
[illegible] that [illegible]
[illegible]
the [illegible] to [illegible]
[illegible] to the
[illegible] side of the valley,
[illegible] had been thrown out for
the [illegible] to the
[illegible] This work [illegible]
[illegible]
as the [illegible]
[illegible] causes [illegible] in the first
instance [illegible] At
this place [illegible]
[illegible] in the shafts
of [illegible] had been
[illegible]
[illegible]
[illegible]
[illegible] was
completed [illegible] subse-
-quent [illegible] to
the [illegible] at this period ~~[illegible]~~
included ~~[illegible]~~ [illegible] in connection
with the [illegible] and
the [illegible] works, as well as
the [illegible] raising the
[illegible] of the canal, construction
[illegible]
[illegible] and [illegible]

[illegible] purpose was taken from
the [illegible] of the [illegible]
between [illegible] and [illegible]
[illegible] feet long, [illegible]
[illegible]

The general design of the
Aqueduct [illegible]
[illegible] the [illegible] in the Atlas. The
total length from [illegible] to
[illegible] is [illegible] feet [illegible]
[illegible] of the [illegible] at
[illegible] to the [illegible]
[illegible]
[illegible] feet.
[illegible] be required
[illegible]
[illegible]
[illegible] in the [illegible]

These [illegible]
[illegible] 100
feet [illegible] ground [illegible]
the [illegible]
[illegible] with [illegible]
[illegible] with the
[illegible] ends of the
Aqueduct [illegible] both sides
of the [illegible]
[illegible] with a [illegible]
[illegible] to the [illegible]
[illegible] was [illegible] to
[illegible] the [illegible] at the
[illegible] was the
[illegible] of the [illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible]
[illegible] the [illegible]
[illegible] was [illegible]
[illegible] to the
[illegible]
its flood [illegible] into the valley
[illegible]

[illegible] work [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] at this point
[illegible] [illegible] explained by a Diagram
[illegible] which the upstream [illegible]
of the Aqueduct [illegible] [illegible].

Diag. CXXXIX

Here A.B represents the Canal Channel intersecting the Burrumpoor Nulla at C; a' b' shows the Cut that has been made to remedy the [illegible] with the drainage caused by the Canal Embankments [illegible] [illegible] [illegible] to pass the flood waters of the Busrumpoor Nulla into the Sohun [illegible] [illegible] of the village of [illegible]. At the point C the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] it will be [illegible] [illegible] the [illegible] of the Aqueduct [illegible] [illegible] which [illegible] [illegible] [illegible].

[illegible] [illegible] more [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] [illegible] which [illegible] [illegible] passage [illegible] safety [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] valley [illegible]

to be used as a [illegible] water, [illegible] the sandy [illegible]. It will be a diversion [illegible] without [illegible] from the [illegible] the Canal [illegible] from drift. They would be brought into operation by working parties who [illegible] earth [illegible] [illegible].

Diagram CXI.

The above Diagram will explain how the Canal is connected with the Rutmoo [illegible]. It will be seen that by closing the Regulator [illegible] at A [illegible] opening the [illegible] the whole of the Canal supply is [illegible]. The Canal channel below the Regulator is then dry, and the water passes down the Rutmoo.

The distance along the [illegible] at A and the [illegible] between the two Escapes [illegible] with that at C is [illegible] 14620 feet. The Channel [illegible] this distance being of a rectangular

with a water section of 140 feet in
width with a vertical side slope
on a depth of 10 feet equal to 1400
feet. Supposing, therefore, that a
serious accident was to occur in
the line of Aqueduct, which req-
uired an instantaneous red-
uction of water necessary the
remedy would be in closing
the Stop-bridge at Futunol, by
which all further access of sup-
ply would be stopped. As-
suming an extreme case in
which at the time the Regulator
was closed, there was a depth of
10 feet of water in the Canal, the
quantity of water which it
would be necessary to get rid
of before the Channel at the point
C was laid dry would be equal
to an area of 14620' × 1500 = 21930000 [cubic feet]
~~[illegible]~~ in a great quantity of
that standing on the Aqueduct
Channel at the time ~~would
have to be got rid of~~. It was
under this view of the question
that I determined in providing
the means of relieving the Chan-
nel from as much of this water
as was possible by making the
Escapes at C. It is by no means
improbable that a more effici-
ent remedy may be inven-
ted in getting rid of the earth
which now fills these Escapes
than that which I propose, the
permanent establishment of
Labour which will be main-
tained for the repair, clearance
and maintenance of the em-
bankments and these slopes
will always, however, be at

raised, a[illegible] as the cutting is
inhabitants [illegible]
is [illegible] a common expedient
in dangerous floods, it is possi-
-ble that the present arrangement
will answer. 2nd I have an objection
to permanent works for regulating
the supply being built either
near the Aqueduct or at this
particular spot: such works
when built in a country like
that of the Khadir had to main-
-tain a quicksand with rank
vegetation on the bed line is
[illegible]; they would be particu-
-larly open to objection from this
circumstance alone, as regards
the health of the neighbouring
country; but the [illegible]
of the means of regulating
supply offered by the [illegible]
or other [illegible] works, renders
for this purpose merely quite
unnecessary. [illegible] C
[illegible]
[illegible] and [illegible]
[illegible] along the
[illegible] [illegible] 2J – 433 Vol II
[illegible] which will Part iii ch IX.
and then [illegible].

[illegible] has [illegible]
[illegible]
the [illegible]
over the [illegible]
so that the [illegible]
[illegible] the
[illegible]

[illegible]
[illegible] 30 [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

of the masonry, is designed to remain [illegible] as an ultimatum as if [illegible] any other steps. And in the present under the extent of durability when compared with that of the steps and arms of the [illegible] afforded security against the [illegible] of the Current. These [illegible] [illegible] [illegible] or Pedestals, [illegible] [illegible] figures of the existing [illegible] monument with their heads [illegible] [illegible] outwards from the Aqueduct, [illegible] or upstream on the upper and down stream [illegible] Sides [illegible].

In the [illegible] of the Aqueduct there are [illegible] objects [illegible] flight of steps, [illegible] the [illegible] to the water is carried for a distance of 75 feet [illegible] with the Cattle [illegible] [illegible] inclined planes extending from the rear of the embankments to the water, the purpose is giving access to cattle for drinking purposes. This inclined plane which is 50 feet in width is crossed by 5 flat masonry arches of 17 feet in span [illegible] [illegible] up the [illegible] of [illegible] [illegible] along the [illegible] Each flank of the Cattle [illegible] is protected by a wall terminating by an Octagon Tower as it has been described in the [illegible] under the head of bridge [illegible] the [illegible] [illegible] a [illegible] of [illegible], [illegible] [illegible] the Cattle [illegible] [illegible] steps like those that are in contact with the [illegible] [illegible] appearance. The bridge [illegible] [illegible] [illegible] [illegible]

[illegible]

wards expanding from a width of 150 ~~at last of~~ 170 feet. These slopes are in direct contact with the face of the Bridge which consists of 3 arches of 30 feet span each with piers of 7 feet, [illegible] consisting as those [illegible] the Bridges described in a former chapter. The Bridge roadway being elevated to a height of 24 feet whilst that of the [illegible] is [illegible] 17, the former is gained by a ramp with a slope of 3.66 in a hundred, the ramp towards the [illegible] being [illegible] by a retaining wall which terminates at the foot of the slope and at the commencement of the arch. The Bridge road way which is horizontal has a width between the plinths of the parapets equal to 17½ feet and the approaches [illegible] on a slope of 2 in a hundred.

The Terminal works including the Bridge and [illegible] [illegible] the extremities are 571 feet in length. The [illegible] is the same [illegible] [illegible] described [illegible] Termini, [illegible] the Bridges the former at Messina [illegible] the latter [illegible] [illegible] feet [illegible] superstructure [illegible] [illegible].

[illegible] the Bridges that constitute the [illegible] Terminal communication, the Culvert [illegible] across the valley may be said to commence. The [illegible] [illegible] [illegible]

[illegible]

within the same scale and slope as those before described, leave the bridge in a corresponding one, and proceed onwards to direct parallel lines, until they come in contact with the Aqueduct profile, on reaching which under which the Reinstatement of the Coleroon River Channel. To meet this breadth the distance width of the channel between the slopes is 172 feet, these Revetments again expand into ogee curves, the extent of expansion being from 150 to 172 feet.

The total length of the revetted Channel on the upstream side is 10713 feet. On its downstream it is 9723 feet. The transverse section is shown in the following diagram.

Diag. CXLI

The design of the Revetments as originally planned and placed in many respects is here as now exhibited in consequence of my anticipation of the difficulty of procuring in great abundance in the neighbourhood and having been realized, and from a desire to reduce the amount of masonry or substitute ... with rough rubble construction; and although considerations ... a small portion had been done previously ...

the [illegible] in 1843, the reasons [illegible] to make it the alteration ap[illegible] [illegible] to me sufficient to [illegible] [illegible] [illegible] to [illegible] [illegible]. By [illegible] Diagram Sections of the [illegible] [illegible] as originally designed, as modified, and as afterwards improved, this part of the work will be perfectly under-stood. —

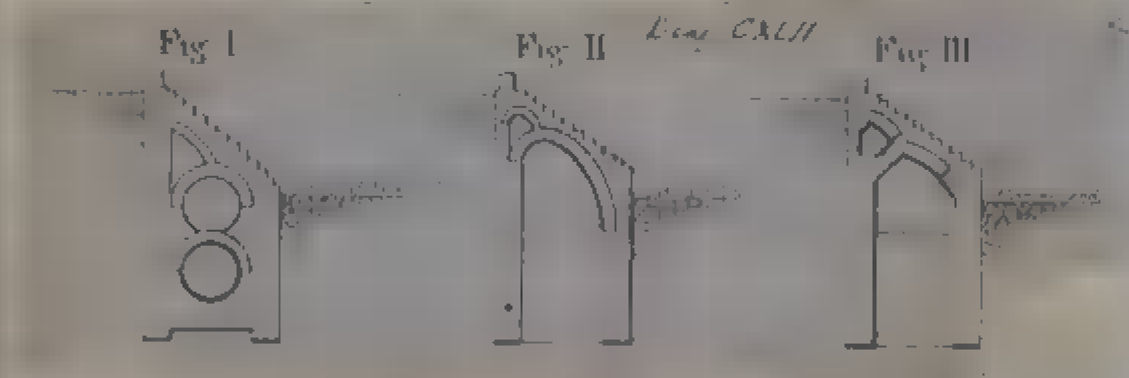


Fig I shows the original design. The [illegible] [illegible] was [illegible] the [illegible] [illegible] as [illegible] was [illegible] [illegible] the [illegible] [illegible] [illegible] earth [illegible] [illegible] [illegible] the outside, [illegible] [illegible] the inside [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Fig II Modified [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] by a [illegible] [illegible] [illegible] being 15 feet, [illegible] [illegible] extend to a [illegible] height of ※ feet. In this [illegible] the [illegible] [illegible] [illegible] that in Fig I [illegible] [illegible]. Its stability however depended on the earthwork [illegible] [illegible] [illegible] of the [illegible] arising [illegible] [illegible] both [illegible] [illegible] [illegible] [illegible] and [illegible]. Consequences [illegible] [illegible] [illegible] which occurred during the [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the parts [illegible] at that time. [illegible] [illegible] [illegible] without [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ~~Design~~ the above [illegible] [illegible] [illegible]. —

Fig: III [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] a portion of the [illegible] that exists ~~[illegible]~~ in Fig: II by [illegible] [illegible]

※ Note. The height varies [illegible] that of the Revetment. The wall being in all cases [illegible] to the height of springing of the [illegible]

the weight [illegible], and by dividing the entire width of weight [illegible] equally throughout the mass

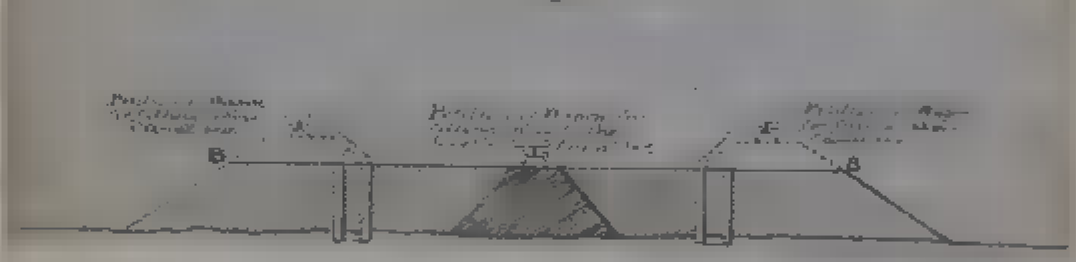
With exception to those portions of this Revetment which were built previously to the year 18[illegible], the whole have been constructed on the design prepared in the 3rd [illegible]. They have been built almost entirely of brick, the exceptions being on the [illegible] side where Kunkur as far as that material could be procured was used, and on the [illegible] side, where a considerable portion of the walls has been built of vitrified masses from the kilns. These vitrified masses ([illegible]) have been used in masonry wherever they were available although they have [illegible] been [illegible] on account of the ballast-ing of the railways.

In addition to the [illegible] which face the Embankments on the sides of the Channel, the exterior [illegible] at each thousand feet of their length accommodated with flights of steps, 10 feet in width, for the purpose of facilitating the communication between the high and low levels; the height of these flights of steps varies with their distance from the [illegible] of the Valley, those which are in the closest approximation to the Aqueduct proper, or to the Channel of the [illegible] rising from the [illegible] to the top of the Embankment 31½ feet. This in fact conveys an idea of the variety of heights to which the section [illegible]

CXLI is subject. From the terminal bridges where the surface of the Earth and top of Embankment are on one level, the height or depth of Revetment gradually increases, until its arrival at the Aqueduct proper on the [illegible] side it is equal to 37¼ feet, and on the [illegible] side 36¼ feet. The [illegible] slopes which I have above alluded to are confined entirely to the [illegible] line of Embankment, but on the [illegible] side being provided on the left with revetments of the same description at the extreme ends which are in contact with the Aqueduct proper and the two [illegible]; [illegible] the right, with slopes at the Aqueduct end only.

According to Diag: CXLI which represents a section of the Revetted Aqueduct in its completed form, the progress of construction will be understood from the following diagram.

Diag: CXLIII.



The [illegible] shade in the centre of the Canal bed represents the [illegible] which was first formed [illegible] to support the rail road. In correspondence with the advance of this road, earth was brought for filling in to the right and left completely [illegible]

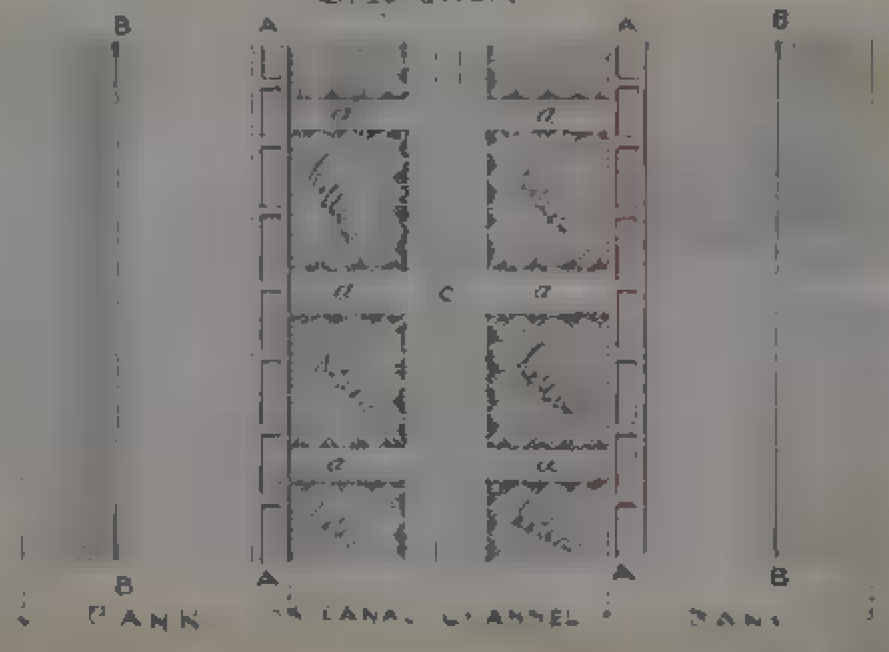
Diag.ⁿ CXLIII

Note for the [illegible]

C. Position of wagon for filling [illegible] canal bed

D. Position of Wagon for filling [illegible] up to the level of Canal [illegible]

mid of BB; this was done in the method described below, its progress was continued through a period of 3 years, and the object was to obtain by a succession of rainy seasons passing over it, the utmost extent of consolidation to the earth



Diag. CXLIV

Diag. CXLIV presents a ground plan of the banks, in which AAAA on either side of the central line of railroad C, the lateral planks aaaa, being roads carried to a level with the railroad, for the purpose of carrying the earth to the embankments by means of the dirt cars, as far back as the lines BB, BB. The spaces between the lateral roads aaaa which left the line of rail at every 200 feet and which are shown in the diagram by shade, were left hollow, so as to act as reservoirs for receiving water during the rains; they acted as ponds for the purpose of distributing moisture by absorption and by these means a gain in consolidation by a settlement. During the course of the period while this was going on, the embankment

in rear of the Revetments as well as the Spaces in the Revetments themselves were in progress up to the level of BB Diagram CXLIII. Early during the season of 1862, and as the works became more advanced the ponds or reservoirs above described were filled in, and work was commenced on the section above the level of BB as shown on the Plans. The plan adopted here was a mere repetition of what had been done in the Canal Channel on the lower levels, that is to say, lines of rails on both banks were started from Muhewac on the higher [illegible] and earth from the Pisan [illegible] ridge was brought forward to complete the work. At this period of our operations a good deal of earth was obtained for completing the banks and their slopes, by excavations from the outer limit of the Side Cuttings as shown in Diagram CXXXVI where the triangle a,b,c was removed and the earth excavated therefrom was thrown upon the Embankment. By this plan we not only obtained earth at a comparatively cheap rate, but we equalized the surface of the ground which in the neighbourhood of the side cuttings had by weathering and by the action of rain water become very irregular. On the Rocky side, local circumstances prevented an arrangement of this sort, in that case the earth was carried [illegible] the rail by incline planes towards the higher levels, and the whole of the embankment [illegible] was completed without the aid of additional railroads

I may observe that even on the Muhewar side, inclined planes of the sort used near Roorkee were practised with great advan=tage to expediting the forming of the rear embankments, here, however, this was the exception, on the Roorkee side it was the general rule. The accidents that took place during the progress of this work were limited entirely to slight disarrangements of the Revetments. These happened during the rains, either by col=lected water passing over unfinished portions of walls, or as in the case of Fig: II Diag: CXLII by the rear wall being acted upon by the thrust of the Arch; [in] these cases an irregular disposition of earth led to disarrangement, but nothing of a serious character occurred, [it] follows that with the exception of the results of a heavy fall of rain that occurred in 1850, when a number of the lateral roads a, a, a, figured in Diag: CXLIV failed, by which the collected water from a ~~[illegible]~~ succession of Reservoirs forced its way along a line of Revetment and knocked down the unfinished end of it, all the disarrangements, slight as they are, which have taken place have arisen entirely from unequal distribution of the earth in connection with the walls. In cases where the Revet=ment has been enveloped both inside and out with earth equally distributed, the walls have not suffered in the slight=est degree.

The way in which the

Earth

earth was carried, the species of draft used, and the rates per 1000 cubic feet of work executed in the Earthen Embankments become a very interesting part of the history of the Aqueduct. It will be recollected that in the early stages wheelbarrows and daily basket labor, were the means by which a good deal of the main body of the Embankment was formed; the introduction of rail roads and wagons relieved us from wheelbarrows and baskets, but for a long time kept us with men both for excavation and for propelling the wagons; as time advanced, horses in some measure took the place of men, and on the 22nd December 1851, we started a locomotive which I believe to have been the first engine of the sort that was ever used in India. We, therefore, went through all the grades of carriage, with varied results, all of which however, appeared to be dependent on local causes, or economical arrangements with regard to time. Our methods of working, therefore, were:—

1st With Baskets and Wheelbarrows
2nd With Earth wagons propelled by Men
3rd With Do propelled by Horses
4th With Do do by Locomotive

With regard to the 1st it is unnecessary to say any particular thing further, than that it led to the introduction of a very efficient species of barrow which is figured in Plate XXVII of the Atlas; and that in using the barrow a ... shoulder strap was

was distributed for the purpose of giving relief to the muscles of the arm; an introduction which was adopted with unlooked for celerity by the Labourers themselves who now consider the strap as a necessary part of the wheel barrow. This circumstance trifling as it may appear, is so far a matter of interest that it shews how ready the native of India is to renounce old habits, and adopt new inventions if he practically comprehends a reason for doing so. The wheel barrow after all however, is entirely European, and is so little understood by the natives of India, that instances have been known, of them having been sent out to Excavators, and used by them as baskets, in filling them with earth and carrying them bodily on their heads!!

The 2nd Item when the Earth Wagon is propelled by men was for a long while the only method used in these works; it has even up to the last been largely practised, and taking the extraordinary cheapness of human labor into account, it may after all be the cheapest. In estimating the value of labor, however, in a large work like that of the Aqueduct, we must look to time as well as to facilities for procuring labourers; the use of cattle, supplies the place of men when such are not to be procured with difficulty, or when they may be more economically employed elsewhere, and in this respect they possess

a value independent entirely of the actual cost of their employment.—

I have before stated that the wagon in use on these works is of a side tilt pattern, it carries from 45 to 50 cubic feet of earth or from 30 to 33 cwt. When men were used in propelling these wagons, 4 Baldans or Excavators were told off to each, one man remaining at his post digging and loosening the earth ready for loading, whilst 3 men were engaged in working the wagon. On the return of the wagon the whole fairly dig, and aid in refilling it. Filling a wagon by two men takes from 30 minutes to one hour, the earth being carried 30 feet on an average: emptying takes from 10 to 15 minutes these 10 to 15 minutes include all the time from the arrival of the first wagon at the spot where the earth is to be deposited to its leaving it again, by which time the last wagon of the train has also deposited its earth and commenced its return trip.

In the 3rd Item where the wagon is propelled by Horses each wagon requires 2 Baldans for digging who remain at the excavations whilst the wagon is performing its trip and who refill it on its return. The Horses in this case being in charge of a Sases or Groom specially paid for the purpose. A Horse travels at the rate of 2·25 miles per hour with a load; and 3·25 miles with an empty wagon. 2 wagons are drawn by

One horse.

Mr Parker in estimating the value of wagon labor with men and horses, has from a series of 5 months accounts in which are included the charges for excavating and carrying 1,317,000 cubic feet of earth, abstracted the following Tables, the first when the wagons were pulled by horses, the latter when they were pushed by men

Table 5.

Average of [illegible] for 1000 Cubic Feet of Digging, [illegible] earth in wagons drawn by horses [illegible] mean distance of 6200 feet by Railway

Description	Average [illegible]	Remarks
Wages of Horses	0.33	[illegible]
[illegible]	0.33	[illegible]
[illegible]	2.??	[illegible]
[illegible] wagons	0.?0	33 [illegible]
[illegible]		[illegible]
[illegible]	0.70	[illegible]
[illegible]		[illegible]
[illegible]	0.??	[illegible]
[illegible]	0.63	

Table 6.

Average [illegible] for 1000 cubic feet of digging and carrying the [illegible] wagons pushed by men to a mean distance of 5700 feet by Tramway.

Description of Workmen	Average [illegible]	Remarks
Wages of Boys	0.51	[illegible]
Digger [illegible]	19.70	[illegible] 50 [illegible] feet [illegible]
[illegible]		[illegible]
[illegible]	1.00	digging [illegible]
[illegible]	0.16	

The cost of digging and carrying 1000 cubic feet of earth [illegible] the last table, was £2.13.1 [illegible] included payment for Sundays [illegible]. Had Sundays not been [illegible] the cost to [illegible] would have been £3. 5. 0.

In the same manner the cost of digging and carrying 1000 cubic feet earth [illegible] Table 5 was £2.19.1, [illegible] as follows:

[illegible]	£0. 1. 10
Digging	1. ?. ?
Carrying by horses	1. 10. 2
[illegible] wagons	2. ?. 3
[illegible]	?. 4. 6
Total [illegible]	£3. 19. 1

[illegible] payment [illegible] Sundays. Had Sundays not been included the cost would have been £3. 2. 6. –

Alder

In the 1st case it will be seen that the distance to which the earth was carried was 920 feet on Railway; in the 2nd case the distance was 570 feet on a Tramway, even the flat [illegible] used before described. –

The above gives a fair return of the average of work done up to the end of April 1881. The following return represents the averages of the 2 following years up to the 30th April 1883, when the use of [illegible] had become well [illegible], and at a time when a comparison between their value and that of men as motive power would be better appreciated. The term "comparison" is perhaps not a fair one to use in this case, as the distance to which the earth has to travel is one of the chief elements in the rates, and this in the latter years has been much in excess to that on which the tables given above have been drawn up. The roads too have been much improved since the early days of [illegible], and the [illegible] and practice [illegible] men and horses [illegible] and expert in their respective duties.

Average No. of Do. required for 1000 Cubic feet of digging and Carrying Earth in Wagons drawn by horses to a mean distance of 11300 feet. –

Description of Labour	Average number
Mates	·62
Diggers	15·65
Men on receiving [illegible]	1·20
Horses – Effective	3·95
do Non-Effective	·84
do do in hospital	1·16

64 Cubic feet = days work of a digger; and 253 Cubic feet = that of a horse excluding Sundays.

The cost of the work is as follows

Excavating	Rs 2·18	per 1000 Cubic feet	or Rs ·050	per ton
Carrying	" 5·43		" ·032	per mile

Cost of Excavating is Constant that, of Carrying varies with the distance – Hence it is 1·43 at 1 mile, 2·86 for 2 miles – and so on.

These averages are obtained from the results of one years work viz: from October 1832 to October 1833. During this time 122 wagons were daily employed, and the total quantity of earth brought down from [illegible] and deposited in the Aqueduct [illegible], was 71,85,378 Cubic feet or 3,51,000 Tons. Each working horse having by this time travelled a distance of 4478 miles or 4 times the distance between Roorkee and Calcutta.

The lubricating material for the axles was a mixture in equal parts of grease or tallow, and mustard oil and the quantity of this required for each Cart daily was 4⅔ Chittacks.

1 Cubic foot of Earth weighs 100 lbs

* weight of the Carts has not been considered

Average of Labor required for 1000 Cubic feet of digging and Carrying the Earth in wagons pushed by men to a mean distance of 2550 feet by Tramway.

Description of Workmen	Average number	Remarks
Mates	·80	50·30 say 60 Cubic feet as the days work of a digger and Carrier
Diggers & Carriers	19·90	
Men on Greasing Axles	·61	Average Cost = 3 Rupees for 1000 Cubic feet

These averages are obtained from the records of 1 years work, leaving out the months of [illegible] May, July & August when the men were [illegible] on account of little work.

During this time 19 wagons were daily employed and the total quantity of Earth carried by them by means to the Ruttnoo Embankments from Petran Kulyeen was 16,52,644 Cubic feet or 73700 Tons. Each Beldar having by this time walked a distance of 1190 miles, a little [illegible] than from Roorkee to Calcutta.

When the Excavator does not carry the earth he [illegible], it will be observed in the other table that he does a daily task of 64 Cubic feet. This reduces [illegible] to 60 feet when he has also to carry the earth, as in this table; so that $\frac{60}{64}$ and $\frac{4}{64}$ will represent the labor done respectively in digging and carrying. In the present case where the two operations are combined Rs 2·34 and Rs ·66 will be what is due to each. The first always [illegible] constant, the latter varies with the distance, and increasing to 1·36 Rs when the distance becomes a mile.

Hence 2·34 + 1·36 = 3·70 Rupees Cost for 1 mile
2·34 + 2·72 = 5·06 " " for 2 miles } per 1000 Cubic feet
and so on –

1[illegible]

On the 4th Item our experience in rates of earth as obtained by the use of a Locomotive was too short to admit of our arriving at any satisfactory conclusions, an accident having placed the machine "hors du combat" a few months after it had been on the works. Lieut. Allen whose establishment had charge of the Locomotive attributes no blame to the parties concerned. The water had been drawn off, and it was supposed that the fire had been entirely extinguished, a storm with wind however, brought the fire and fuel which [illegible] the furnace into action, [illegible] the casing and a number of the tubes, and placed the Locomotive completely out of use. This misfortune although it put a stop to the use of a power which I had anticipated [illegible] that would be of great service to us, and in some degree make us independent of [illegible] or diggers, may not be considered altogether as the cause of the Locomotive having been discontinued. Valuable as it was as an adjunct to the motive power which we already possessed, it had the inconvenience of occupying an entire line of railway to the prevention of its use by the numberless wagons that were required not only for earthwork but for the carriage of materials. We had not a sufficiency of road to provide separate accommodation for it, [illegible] (as time was a great object) to make [illegible]

for the purpose of keeping the engine at work. Horses appeared to be in sufficient abundance, and the horses used at this period were very generally employed, gave steady occupation to the wagons, whilst the constant interruptions arising from repairs to the Locomotive presented me a very serious drawback. This evil might perhaps have been remedied had we, instead of having only one, had two Locomotives, by which a [illegible] might have been substituted for one [illegible] machine, but there can be no doubt that although the Locomotive that we had was placed in the hands of a practical engineer, Mr Broadbent, who (although he had never been actually employed as a driver on steam railroad) had all his life been connected with steam machinery, the engine was in some way either imperfect in the adjustment of its ~~[illegible]~~ parts, it was continually getting out of order, and appeared to be another specimen of "machinery for exportation to "the Colonies".

The Engine that we received at [illegible] was made by Fawcett & Co, it is small and compact, [illegible] and [illegible] in its [illegible]; adapted from its water and fuel arrangements to moderate distances only and applicable to draw on a level line of Rail a train of Ballast wagons of an aggregate weight of 100 to 200 tons at a speed of [illegible] miles an hour. Of the parts most liable to [illegible]

we have duplicates, as well as other wheels with driving, tail and leading. The name is the "Pioneer." The Executive Engineer in charge of the Northern Division of the Works in writing to me on the subject of its applicability to the particular duties which the Aqueduct works [illegible] upon it, remarked "The Locomotive started first on the 24th December 18[illegible], at the [illegible] end of the railway, my intention being to teach natives to drive at that end, as being [illegible] to [illegible], where other duties required his presence in the workshops. Moreover the employment of the Locomotive on the [illegible] aqueduct would have thrown a large number of hands out of work, and would also have seriously interfered with the [illegible] arrangements at that [illegible] in respect of carriage of materials. It soon became necessary, however, to repair the [illegible] line which is laid with flat rails, and what with these repairs constantly [illegible] going on with the [illegible] of other sorts, Mr. [illegible]'s attention being much required to the remaining Engines and workshop machinery, at first the driving did not progress as [illegible] fast. After operating upon it became evident that the machine could never be made available for the Locomotive over [illegible] to its weakness, and but for the necessity of teaching natives driving, whilst

the

the weather was cool, I would have preferred shelving the Locomotive for the time being. As it was, directly I was satisfied of the impracticability of working the Locomotive on the Roorkee line, the new Muhewa Embankment line was pushed on as rapidly as possible, and on the 15th of March last having a portion of the latter line on which horses could work, although still under some disadvantage, the Locomotive was removed over to the other side of the line, and the subjoined table will shew its performances during the remainder of that month.

Date		Number of Loads	Quantity of Earth carried	[illegible]
1852			cubic feet	running feet
March	22	30		
	23	23		
	24			
	25	20		
	26			
	27		18057	15000
	28			
	29	75		
	30	89		
	31	90		

Captain Goodwyn continues "that nothing but the necessity of teaching natives to drive during the cold season, and shame at seeing the Locomotive standing idle, has induced me to allow it a place on the Muhewa Channel line. I have done it in spite of my better judgement, and now the running of the Engine is getting into order, I do not like to break up the arrangements, although until the Muhewa Embank-

-ment-

ment railway is run out much further, we are, I consider, using the Locomotive at an extravagant loss".-

"The want of progress of the Muhewa Embankment railway has been caused indirectly by the sickness of the officer in charge, I have done my utmost to push it forward since the middle of February. During the month of April the work of the Locomotive has shewn a considerable improvement, and once the Engine has brought 114 loads during [illegible] day. Advantage was taken of the presence of the only well [illegible] driver having required at the Roorkee workshops to [illegible] the [illegible] Engine in a few days, to take up the [illegible] portion of the line traversed by the Locomotive laid with flat iron, substituting in its place English rails. During this operation the working of the Locomotive was stopped and hence its progress report for April will show rather poorly"

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Date	[illegible] of working	Number of Loads drawn	Quantity of Earth drawn	[illegible]
			[illegible]	[illegible]
April 1852	10	657	34350	14,000

[illegible] 16 days [illegible] 16½ trips were made [illegible] an average of 41½ loads per trip or 68 loads per diem

Hull

At a rate of about 10 miles an hour, the Engine with an accommodation carriage and string of 10 loaded Wagons passed over the rails very easily and quietly; the difference between the motion when passing over the English rail and the Iron bar, being as I before remarked very remarkable, the former being as different to the latter, as a Kunkur metalled road is to a common District one. Mr Murdoch on this occasion as he had on former ones, adverted to the absence of Coke, and the use of wood and charcoal as a great loss to our Steam Furnaces; he informed me that even on the short distances upon which the Locomotive ran which at that time did not exceed 1½ miles, he was forced to carry an extra wagon for tender purposes.

As an aid to our operations in constructing the Aqueduct, the Locomotive has been a failure, not from its want of value as a motive power, but from its inapplicability to the local circumstances under which the work was carried on; the extract above given from the Executive Engineer's report shews very plainly the difficulties under which he laboured.

The Engine attached to the Locomotive was in its original design so contrived as to be adapted to use as a fixed one in the workshops. In so far

Engine, our want of success on the road has been met by the introduction of by no means an useless addition to our workshop steam power, whilst at the same time the Engine is available for its purposes as a Locomotive at any future time when it may be wanted. I fully anticipate that such will be the case on the railroads that will ultimately be established on each of the Aqueduct Embankments extending from Roorkee to the Solani, here the immediate despatch of stores & materials, or in the case of Earthwork repairs, the rapid collection of material for the purpose, will be very satisfactorily met by the presence of a machine of this description.

From the above it will be seen that to men and horses we have been indebted entirely for the progress made in the execution of the Earthen Aqueduct. This progress has been from early in 1848, up to the 8th April 1852, in a state of steady advancement, and both our men and our material are in a high state of efficiency.

The two following tables will give an idea of the rates of Earthwork as executed, they are those charged by the Executive Engineer in his Quarterly Bills and include all contingent expenses dependent on the repairs and maintenance of the

the plant. The first shews the cost where men are used as propellers to the wagons, the latter where horses pull them.

Rates of Earthwork as executed on the [illegible] Earthen Aqueduct in Ballast Waggons propelled by men

Distance in Feet	Rate per 1000 Cubic Feet including spreading	Not spread	Remarks
447	.. 7 0	.. .. ..	Ramm[illegible]
1500	4 4 10	.. ..	
1500	4 13 ..	.. ..	
2000	5 2 4	.. ..	Trimmed [illegible]
2000	3 2 5	.. .. ..	
2000	5 3 8	.. .. ..	Carried [illegible]
2760	3 4 6	.. .. ..	
3070	3 12 2	.. .. ..	
3240	2 15 5	.. .. ..	
3200	.. .. ..	2 5 4	
3387	3 10 2	.. ..	
3483	3 4 10	.. .. ..	
3418	6 6 11	.. ..	Carried [illegible]
4000	2 4 9	.. .. ..	
"	3 2 5	.. .. ..	
"	3 3 8	.. .. ..	
"	3 4 1	.. .. ..	
"	3 .. 9	.. .. ..	
"	3 3 8	.. .. ..	
"	3 4 12	.. .. ..	
4020	3 13 5	.. .. ..	
4030	3 15 2	.. .. ..	
4120	3 14 ..	.. .. ..	
4100	3 6 8	.. ..	
4200	4 1 6	.. .. ..	
"	4 2 4	.. .. ..	
"	.. .. ..	2 15 0	
"	.. .. ..	2 13 4	
4433	3 7 4	.. .. ..	
4440	3 14 2	.. .. ..	
4720	.. .. ..	2 14 7	
4766	3 11 8	.. ..	
4447	3 14 2	.. .. ..	
5000	.. ..	2 13 10	
5200	.. .. ..	3 14 1	
"	.. ..	3 15 7	
5850	.. .. ..	3 7 1	
5306	4 2 5	.. .. ..	
5400	3 8 9	.. .. ..	
5407	.. .. ..	3 14 1	
6594	4 3 11	.. .. ..	
6800	4 1 8	.. .. ..	
7000	3 11 10	.. .. ..	
7215	.. .. ..	3 11 3	
7672	.. .. ..	3 5 ..	
7702	.. .. ..	3 0 2	
7783	4 7 6	.. .. ..	
8000	.. .. ..	3 2 6	
"	.. .. ..	3 13 10	
"	.. .. ..	3 14 8	
"	.. .. ..	4 4 1	
8180	.. .. ..	3 11 5	
8290	.. .. ..	3 8 3	
8446	.. .. ..	3 8 2	
8456	3 4 10	.. .. ..	
8500	.. .. ..	4 4 4	
8843	4 10 7	.. ..	
9000	.. .. ..	7 4 ..	
9030	6 4 1	.. .. ..	
9186	5 13 1	.. .. ..	
9365	5 3 11	.. .. ..	
11200	.. .. ..	4 0 0	

Rates on Earthwork [illegible] executed on the Solani Earthen Aqueduct in Ballast waggons drawn by horses.

Distance Running Feet	Rate per 1000 [illegible] inclusive of spreading	Remarks
7000	3 4 6	
7500	3 4 10	
8673	3 8 10	
8540	3 13 [illegible]	
8840	4 15 3	
8960	5 7 10	
9400	5 9 10	
9600	5 4 0	
10110	4 12 [illegible]	
10780	5 0 8	
10763	5 9 1	
11200	5 .. 5	
..	5 15 5	
11540	5 [illegible]	
11622	5 3 [illegible]	
12000	5 12 9	
12005	5 4 3	
12400	5 [illegible]	
14430	3 13 4	[illegible]
15000	4 3 [illegible]	[illegible]

The Sectional form of that portion of the Aqueduct which we are now describing is shewn in Plan: CXLI, ~~which~~ represents the work as it will be on the completion of the boulder bed, ~~which it is proposed~~ to be extended over the whole of the Eastern Channel, as a protection against the wear and tear of the current. The depth of this layer of boulders (or round stones from the Ganges River and its neighbouring branches) will be two feet, the stone ought to be of the largest description procurable, as its value for the purpose intended will depend in a great measure on its consistency. To relieve the works from such a heavy cost, as the transport of so much material by land carriage would entail upon the Estimates, this portion of the undertaking has been reserved

until

until after the admission of water into the Canal, when the facilities offered by water carriage will render this part of our operations comparatively simple. For this purpose a number of Iron boats have been built ready to put on service immediately the time for floating them arrives, these with the boats which have been used for a considerable period on the Navigable Canal for the same purpose in bringing stones from the Ganges to the Ranipoor works, will give a very good fleet to begin with. I would recommend however, that the manufacture of either the same class of boat now used, or of a better sort if such is thought necessary, should be continued, until there is a sufficient number to provide bridges at the different navigable heads, as well as for the transport of stone; for these purposes at least 200 boats might be completed with very great advantage. At the present stage of the Eastern Aqueduct, the Canal bed is raised ~~on an average 1½ inches~~ above the true level, so as to admit of settlement and consolidation, the delay in depositing the stratum of stone will be so far advantageous, that it will give time for this consolidation. Taking a practical view of the method to be adopted* in the immediate vicinity

*[illegible] down the stone, I would [illegible] recommend that it should first be completed.

gravity of the Aqueduct proper, or in those regions where the bed is the most elevated, and where the side revetments are necessarily the least protected. After this was finished, a width of 10 feet or thereabouts, laid in on the sides of the channel nearest to the Revetment walls in the whole length of the Earthen Aqueduct would be the most desirable provision for the stone. The Centrical part of the channel would be the last in sequence of this most necessary part of the operations. A good deal of settlement, and probably of an irregular nature may be anticipated in such a long line of artificially raised earth, a careful watching of progress in this point will eventually be the earliest consideration, and it is my opinion that many years will elapse before we can hope for the establishment of a bed sufficiently permanent to admit of the full supply, nor can this permanent bed be hoped for, until the stratum of stone has been laid over the whole of the surface. It is in vain to expect immediate results in the early delivery of large masses of water upon the high land of the Doab at Roorkee, until the works in the Khadir especially those appertaining to the Solani valley are fairly established. The delay that is anticipated is from the bed of the Earthen Aqueduct

Aqueduct mainly, the effect upon that part of the work, but as the means by which we can regulate the admission of supply; the constant necessity for laying this work dry, and the interference of damage to the purpose of irrigation, the action of the Ground are matters upon which it will in all eternity, and in fact its early efficiency as a permanent work on which the carriage of a body of water depends. The feelings of disappointment, and the desire for speedily gaining results, ought to militate against the causes which I have now recorded. The works are of a nature not common in any of the Canals yet constructed in these Provinces, and I believe that the difficulties which we have had to contend with, and with the impracticability of the finding a Stone Foundation, the circumstances that their natural obstacles, will be hereafter (even when canals are taken from all the great Rivers that debouche from the Himalayas as they no doubt are) a remarkable feature of the Ganges Canal works. At any rate the present unfinished nature of these works demands peculiar treatment, and it can only be by slow and deliberate management that they can be expected to answer the purposes for which they were designed.

Turn — For the [illegible] now form [illegible]

to say a few words, in closing this section, on the masonry works which are attached to the Eastern portion of the Solani Aqueduct. I have described their design and would for further explanation on this point refer to Plate XXVII of the Atlas where drawings are given in detail. The terminating bastions or the circular masses of masonry which come in contact with the Canal Channel on its approach to and departure from the Aqueduct, owe their decorative character to the figures of lions on the pedestals [illegible] [illegible] skill of Lieutenant Price, of the Bengal Artillery, the Assistant Engineer under whom the Aqueduct works were constructed. The figures although rather [illegible] in stone, but of plain [illegible] work, have the merit of being made from the material to which our resources have [illegible]. In this respect they are [illegible] of the case more satisfactory than had they been of a higher order of art imported from Europe. [illegible] specimens of the work of our own Engineers, and as such are well deserving of notice. [illegible] they are built, with a [illegible] [illegible] [illegible] they are [illegible], and as [illegible] [illegible]

there are will be also on these pilasters, and look outwards from the Aqueduct.

The Bridges are as I have before noted, of the design described as Class No 1 in the Drafts of Bridges, Plans forwarded with the Estimates; Surmounted by raised pilasters, the water then consists of 2 bays with elliptical arches of 55 feet span each, for a distance of 350 feet on their up and down stream faces, on that portion of the Southern Aqueduct which is described on both sides, the steps are thus cut off from the towing path which passes round to a ramp made to facilitate its [illegible] [illegible] the discharge of the accommodation to bathers who can [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] The line to Cattle in each flank 12 feet [illegible] [illegible] [illegible] the face of the bridge, [illegible] [illegible] the steps for the [illegible] of passage between the high [illegible] landing.

The Cattle ghats would be between the Ramps and the Cart Roads of approach to the Bridge, and would no doubt be duly appreciated by the Village Community, in the accommodation they offer to their Cattle; in addition to this at low water they might [illegible] [illegible] point for the loading or unloading carts [illegible] the [illegible]

Plans

places upon which they are built are well adapted. I have however observed that the line of communication along the Berm is maintained across these Cattle Gates by arches which render the whole an unbroken and continued line.

The Revetments were laid in to a depth of 12 inches below the natural surface of the valley, they were either filled with earth consecutively with the progress of building, or the earth was thrown in afterwards, upon this earth which acted as centres, the arches were constructed, so that the whole mass is formed of well consolidated earth, protected on the sides & the channel by masonry.

The mode of construction, viz. throwing the walls and bulking it up with earth, the rules which devolved among the [illegible] were 1st. That taking the proportions of Drawing CLXII it appeared to me doubtful whether the walls were sufficient for the height without the interior support of earth, especially when the height of the Revetments was at its maximum, [illegible] there [illegible] taken into consideration the possibility if not certainty of the interior being filled with water, as well as the chances of the action of the ground causing the channel bank [illegible] to a considerable depth. The [illegible]

[illegible]

hollow shell offered by the Revet-
=ment figured above appeared to
me to be an insufficient protection
to the Embankments, and with the drains,
to give facilities for leakage.
On the other hand, well rammed
clay in the interior would add
to the water tightness of the Chan-
=nel in its elevated position above
the valley; the construction of the
Arches and building in general
would be greatly simplified by
the interior being filled with
earth, and the only objection that
existed, as far as I could gather,
was from the effect that absorp-
-tion of moisture by the earth
or clay might have upon the
enclosing walls. The advantage
in favor of solid over hollow
Revetments appeared to me to
be sufficient, to prevent the ob-
-jection above specified from
influencing me in the selection.
The value of these Revetments
depends so much upon the
efficient maintenance of the
Canal bed, that in giving all
our attention to protecting the
latter, and in strengthening
it by all the means in our
power, we in fact do the same
service to the Revetments.

I have before remarked
that with the exception of Kun-
-kur and vitrified brick which
comparatively speaking have
been very sparingly used, the
whole, the Revetment and terminal
works are built with brick
masonry, with a Lime Cement
mixed in the following propor-
=tion

-tions

1 part of Stone Lime
1 — do — Soorkee
1 — do — Sand

The brick has been denominated 2nd Class from the circumstance of the best having been selected for the Aqueduct proper, for the bridge Arches, and for other portions of the work where the hardest material was required. although bearing the name of 2nd Class, and not so well burnt as the other, it is not to be understood that the brick was of a bad quality, the material was sound, and well burned, and would have been received as such on any large board of works. These bricks in fact were very much better than those used for building purposes in England, and as far as I observed, equal to any that I saw on the Continent of Europe.

The whole of the outer surface has been Stuccoed with a Cement of the following proportions.

1st Coat { 1½ part of Stone Lime / 1 — do — of Soorkee.
2nd Coat { 2 parts of Stone Lime / 1 — do — of Soorkee.

I have in Plate XXVII Atlas, Sheet No 14, given representations of the Kunkur and vitrified brick building as executed; the former when not laid in blocks was used as beton enclosed in brick work, strengthened by brick bond; the latter is in horizontal courses, alternating with Brickwork the alternating lines being

bounded

bounded by brickwork intro-duced vertically at fixed dis-tances. –

The above gives as full a detail as appears to be neces-sary on the Earthen Aqueduct line, the great extent to which it is carried rendering it the largest as well as the most important part of the Ganges Canal works. – We now, there-fore proceed to describe the Aqueduct proper, or that portion of the works over the Tolani River which comes in imme-diate contact with the Torrent for the passage of which provi-sion has been made below the levels of the Canal bed. –

Section II. Masonry Aque-duct connected with the Solani Torrent.

On my return from England early in 1848, I found that the block sinking of the foundations had been commenced, that the whole of the blocks of Six piers on the right or Roorkee side had been completely sunk, and that others were in progress. Re-ferring to Plate XXVII of the Atlas at the period ~~that~~ I allude to, the state of this portion of the work was as follows: –

Completely sunk: Nos 40. 41. 42. 43. 44. 45. 46. 47. [illegible] 56. 57. 58. 59. 60. 61. 62. [illegible]. 72. 73. 74. 75. 76. 77. 78. 135. 136. 137. 138. 139. 140. 141. 142. 151. 152. 153. 154. 155. 156. 157. 158. 167. 168. 169. 170. 171. 172. 173. 174.

In progress of sinking: Nos 102. 103. 104. 105. 106. 107. 108. 109. 110. 119. 120. 121. 122. 123. 124. 125. 126.

some subsequent encroachment in the
way of Coffer dams for the pro-
tection of the above abutment,
a cut [illegible] made on the left of
the town, to facilitate the passage
of the Stages on the Dover Stage
side of the works, and which is
distinguished among [illegible] under
the name of "Tracey's Cut"
has also been done. The state
of the works on my return was
that of full progress in block
making.

Various alterations had
been made in the arrangement
of the blocks, of the abutment
and towers. Tiers of blocks had
been recommended by Major
Baker in substitution for the
stone facing which was proposed
to be placed in rear of piers,
and the buttresses which had
been [illegible] designed as having been pro-
posed as ornamental appendages to
the towers and afore [illegible] have
been intended to be founded on
blocks sunk to an equal depth
with the rest of the foundations.
The alterations made to the abut-
ment blocks depended on an
increase to the thickness of the
Abutments themselves, which
from 15 were extended to 24 feet.
The blocks in the towers had
been altered likewise, for the
sake of economy, the bonded
large blocks which were originally
designed having an angle face
to the outer [illegible] area, and
a [illegible] tier of blocks of a
smaller size. The substitution
of blocks for filling at the head

and

and that of the Aprons, and giving massive foundations to the Cutwaters, was to reduce as far as was possible the effects of the water, and generally the subsoil from the flowings as well as to give to the floorings and to the protective arrangements in that part a real, greater strength and stability than was previously offered. The whole of these alterations were carried out as far as they could be.

Arch. The Superstructure of the Aqueduct is unaltered in its original character from that which was originally designed, additions have been made in connection with the Canal head both on its up and downstream ends, and in details of construction slight deviations (all of which will be described in their proper places) have been made adapted to particular circumstances.

In Elevation the design architecturally speaking is the same as it was originally planned in my Report of 1839 &c. The wings have been altered to broken rusticated basements supporting pedestals and the Pilasters over the Cutwaters have been pierced by Circular holes which are intended for the ventilation of the Spandrels, these with a few of Cutwaters somewhat modified

for

[illegible] the only deviations [illegible] the only deviations from the design as first contemplated.

The text will be understood by reference to Plate XXVII of the Atlas, and to the drawings, plans which show the [illegible] in the [illegible] valley. The avenue up from the valley it consists of 15 Arches of 31 feet Span each, the two [illegible] Arches being terminated by [illegible] Wings, each of which support pedestals, on which are Lions similar to those found in the Funereal tombs, although of larger proportions. These Lions face inwards, looking towards the [illegible]; and guarding the Portal by which the Funeral procession passes through the tomb. They ~~[illegible]~~ the position of the ~~Sphinxes at the~~ Egyptian Temples, ~~the~~ stream ~~[illegible]~~ of the [illegible] passing ~~between~~ the guardian Lions ~~[illegible]~~ to the all absorbing ~~[illegible] of the~~ Ganges; as that in the [illegible] to Egypt ~~may be supposed to have done~~ ~~[illegible] through the~~ ~~[illegible]~~ towards the ~~[illegible]~~ which [illegible] ~~[illegible]~~ to the Altars ~~[illegible]~~

They are in truth arranged as were the Sphinxes in the Egyptian Temples and as in those of the stream of Nile worshippers on between these guardians to the vast Propylaea shutting the approach to the Altars, so the Solemn [illegible] passes the same stream of the Ganges between guardians equally appropriate [illegible]

The foundations of this building [illegible] in first consideration. [illegible] have described the nature of the Stone, the [illegible] character of its bed, its [illegible] [illegible] Springs; and have mentioned that although during floods it is the bearer of an enormous quantity of water; at

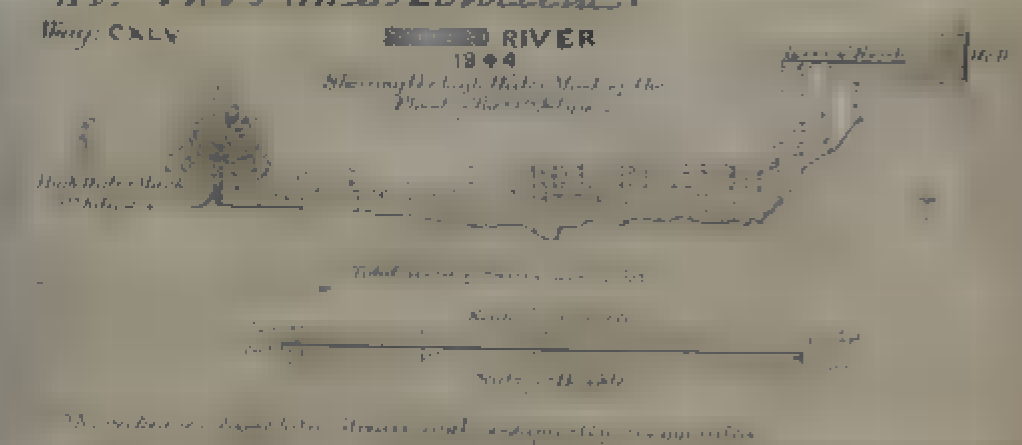
discharge of the stream is quite insignificant, varying from 8 to 20 cubic feet per second, whilst in extreme droughts, a superficial run of water ceases altogether. As the dimensions of the foundations are dependent on the amount of waterway of the superstructure, the circumstances by which this was determined may be best explained before I commence upon the details of construction. The original design of the waterway of this work which accompanied my Estimates of 1842, gave 6 bays or openings of 50 feet each, or an opening in the aggregate equal to 300 feet; this was founded on calculations of floods observed by the natives, verified in some degree by existing marks of high water. The results were obtained from observations hastily taken during the course of a survey which with its field work, plans, estimates and report were all concluded within the space of five months. Further observations, however, appeared to sustain the conclusions of these calculations, but in 1845 a flood which occurred during the residence of Captain Turnbull of the Engineers at Roorkee, although it did not exceed the capabilities of any Aqueduct led to speculations as to the propriety or otherwise of extending

the dimensions of a work upon the stability of which the Canal depended. In submitting my report (with Estimates) of 1845, therefore, I went into some detail on this matter, and as the remarks that were then made will be interesting as shewing the gradual progress by which the Aqueduct reached its present dimensions I shall here state the views which I then held, premising that up to the year of 1844, I had determined on so far modifying the former design as to give a clear water way of 500 feet broken into 10 spans of 50 feet each, with a reduction of dimensions to the piers so as to render the obstruction as small as possible. "In the above Estimates I have raised (in reference to those of 500 feet waterway) for the passage of the Solani valley, I have with reference to the probable height of the most extreme floods, projected works which from the calculated discharge and area of the flood water of the Solani River appear to me to be amply sufficient; there were no indications of floods having reached to a higher level than that shewn in the Sections above given, and the cultivated state of the tract of low land lying between Bajoheri and Roorkee did not tend to the most remote inference that floods ever occurring

of

of such a magnitude as to lead to their entire inundation.

The following Section is that of a flood which occurred on the 28th July 18.., the extreme height exceeded by 3 feet that which had been supposed to be the maximum.



By referring to the section of the valley between Nagurkee and Roorkee, it will be observed that the inundation was, supposing this flood, extended across the whole breadth, the duration of the extraordinary did not continue beyond an hour or two in the middle of the day, but at 7 P.M. it was running at a height equal to the highest flood of 18... I had in my report of that adverted to the circumstance of the country lying at the foot of the Sewaliks being occasionally visited by floods of extraordinary magnitude, and that in projecting the works was of the Solani Aqueduct, the passage of unusual floods had been provided for. This which was written in 18.., was justified by an experience of 1.. years passed in contending with 3 of the mountain streams connected with the Sewaliks 2 of which were first-rate.

Wiltshire

of
the capriciousness of these Tor-
rents I had yet been an in-
attentive observer. - The pe-
riodical occurrence of remark
able floods, confined apparent-
ly to the water shed of the
Jumna was exhibited ~~in the~~
rains of 1842. The fall of rain
which led to the floods of that
year appeared to be confined
entirely to the Sewalik Hills
and to the forests lying at their
base: the Mountain streams
and Rivers connected with them
[illegible] with the Jumna ~~water~~ Drainage
basin ~~[illegible]~~ were charged with a
supply of water not known
[illegible] for many years. The
[illegible] canal works suffered
[illegible]ly. The Bridges on
the road between Saharunpoor
[illegible]
which had remained
uninjured since they were
built (about 25 years before) [illegible]
[illegible] the Jumna, Mindun,
[illegible] nalla nuddi and the
streams tributary to them were
also suffering in a greater or less
degree; yet during this excessive
flood which affected the Country
[illegible] at the head of the East
nalla nuddi, the Solani River
did not rise above the extreme
high water mark noted in the
[illegible] that accompanied my
[illegible] in 1841. The remarkable
fact is that although the
drainage that supplies the
Solani is perfectly distinct
from that which feeds the Rivers
above

above alluded to, the waterheads of each are in contact, and it was natural to infer that the heavy rains that led to the floods of the Jumna itself, were common to the line of Hills and Forests extending over the heads of the Solani. Local falls of rain however, are by no means of unusual occurrence in these regions, they in fact become one of the many difficulties with which we have to contend in our devices for regulating supply, and frequently lead to catastrophes at one point of the works when at others no rain has fallen at all. During the floods of 1842 to which I have above alluded, as causing such destruction to the bridges connected with the Rivers under their influence the high water in the [illegible] Bridge (a work built over the Hindun not far from its confluence with the Jumna, although a long way below the junction of the Dumla, west Kalli nuddi, and other tributaries to which it owes its supply) was very much in excess to that of 1845. Here, again, local circumstances affected the magnitude of the floods. In 1842, the dams which are connected with the Eastern Jumna Canal works, and which are raised to prevent the water of the Mushkurra from reaching the

the works, by throwing its supply into Cuts connected with the Mendun, remained uninjured during the rainy season, whereby the whole of the drainage from the Sunsurra and Kalowala passes flowed down the Mendun. In 1865 on the contrary, the bunds in question broke, and the Mendun was thereby relieved of so much flood water.

I am prepared for the remark that with such an extended section as that shown in Diag: CXLV, a portion [of the] water would be still or merely inundation; it is difficult to say to what extent this might exist, and the impracticability of measuring the different velocities in different portions in the width of a river of this description so as to obtain an approximation to the mean of the whole section, leaves us entirely dependant on calculations based on the observed slope of the bed of the River; which although they may be considered accurate when the stream in the channel of a Canal or River is confined and of one depth & section, are not to be depended upon in floods rising above the banks, and inundating the neighbouring country. As an extreme illustration of this we may refer to Diag. CXLV,

(see [illegible] H, vol 2, p. 3, c ix) Wilkins[illegible]

[illegible]

which merely exhibits the section immediately in the region of the head of the Current; now calculating thus with reference to mean velocity deduced from the slope of the River, we have a discharge per second equal to 84108·62 cubic feet, a volume of water which is ten times as much as that which flows in the Ganges during the dry months of the year, and half as much as that of the Rhine on the French frontier which is said to be equal to 163253 cubic feet per second. It is impossible to consider (when [illegible] along the surface of the country as bounded by the water heads of the stream above the Aqueduct or in other words the catchment basin which throws its water upon the point where the above section was taken) that so much rain could have fallen, and the inference necessarily is that the mean velocity of the water running in the above section could not have corresponded with the slope of the bed of the current. I may observe that the section to which I am referring was by some mistake or other taken obliquely to the course of the River a circumstance which "per se" affects its value. The results of this observation were not deemed of great importance, the flood to [illegible] such extraordinary amount [illegible]

Jumna as well as on the Ganges
water shed, Villages built on ground
usually out of the reach of high
water mark were swamped and
cattle drowned. Old branches of
the Jumna which for years had
been dry, and which previously
to the floods of 1844, were covered
with Forest and gigantic Bur
and [illegible] trees, shewing how
long they had remained free from
the effects of flood or running
water, were during this year
swept out, and restored to their
former state of River beds; from
this too we find we date very ex-
traordinary changes to the amount
of water thrown down the Boodhee
Jumna during the rainy season,
and the drying of others which
in preceding years had been com-
paratively unknown. For
[illegible] the subject of the
floods of 1844 and [illegible], and
in further exemplification of
their height in the latter year,
I append a diagram of observations
taken by me in the cold weather
of [illegible] on the main Jumna
at Rajghat in the Deyra Doon.
The site where the section [illegible]
[illegible] this series was taken
was at the Ferry immediately
below the River enters the Sewalik

JUMNA RIVER at RAJGHAT [illegible]
DEYRA DOON
Shewing the height of Floods in the Rains of 1844 in connexion with those of other years

Diag. CXLVI
[illegible] Doon

N.B. The Floods of 1844 stood over the floor of the hut at A, the [illegible] [illegible] near them were swept away with Timber of all sorts [illegible] and [illegible] [illegible] [illegible] to be perfectly safe and out of the reach of Floods.

Note for the printer
B. Level of bank top
C. High flood. 1844.
D. Said to have occurred about 20 years ago.
E. Common Rain floods
F. Level of Jumna 5th Nov. 1844
G. The river flooded all that low land.

Cummins

it lies between the junction of the Girree and Asun rivers with the Jumna, a point that I was well acquainted with, from having annually, for many years, fished in its neighbourhood; my surprise in observing the effects of the floods at this point was very great, large tracts of elevated land on the edge of the River which had been always in my recollection used as stacking places for Timber, were washed away; the shape of the River was changed, and the Giree which in former years entered the Jumna at a point to the right, immediately above the site where the section was taken, had taken up another position lower down.—

In considering the floods both of [illegible] and [illegible], it became evidently necessary to anticipate the recurrence of similar or even larger ones, and with this view I increased the waterway from 10 to 15 bays of 50 feet each, giving a total width of 750 feet, by adding counterarches and otherwise strengthening the floorings, and by remodelling the transverse section of the superstructure to meet the increased head water, the capacities of opening for the torrent were sufficient for floods of even a greater magnitude than those of [illegible].—

The improved section of this

this period will be understood by reference to the following diagram, shewing the waterway formerly proposed, and those determined on in 1845. It is interesting to place these sections upon record, that we may compare them with that which was ultimately built.

Diag. CXLVII

The design of the foundation was adapted to a water way of 16 spans of 50 feet each with piers of 11 and abutments of 21 feet in width, the latter being flanked by the wing buildings which were connected to and continuous with the abutments and embankments of the Solani Aqueduct. The extreme width of the channel for carrying the canal water over the Solani, including the [?] waterways, was 19½ feet. The total superficial area that the body of the Aqueduct covers was 7,844 feet or 93½ feet in length and in breadth 19½ feet; [illegible] in this series of foundations which were distinctly for the support of the superstructure, there were [illegible] no lines of blocks in substitution of the sheet piling which had been originally proposed, as well as blocks at the [illegible] points of the piers for the

the support of the Actuators.— These, with the blocks for the support of the wings and lines of Revetment forming the flank approaches to the masonry from the Eastern Aqueduct, constitute the work to be done in block sinking.

The total number of blocks which are included in the different parts of the work above referred to, amounted to 338 & which for the convenience of reference and account, were numbered, and were divided into 4 classes depending on the horizontal measurement. These classes were as follows:

Class	L	B	Number	Total Number
1st Class	26	22	16	
	25	20	4	20
2nd Class	22	20	112	
	20	18	8	120
3rd Class	21	10	12	
	14½	14½	60	72
4th Class	20	8	28	
	22½	6	8	
	20	10	2	
	19	10	6	
	17	10	4	
	20	6	52	
	15½	6	26	126
		Total		338

In addition to the above the flights of steps, built in the form of Quadrants which terminated the Aqueduct wings, and acted as returns to the Embankment Slopes on their reaching the Aqueduct proper, were built upon circular wells, of which there were 4 to each Quadrant, or to each flank of the main building. The total number of these wells was 16.

The plan of the foundations in all its detail is shown in Plate XXVII of the Atlas; this plan exhibits the precise position of

of each block when first built, and as laid in the true align-ment of the work, it also shews the state in which the different blocks existed, after their under-sinking had been completed, and after the blocks themselves had passed through the ordeal of the downward movement which necessarily more or less affects their position. A careful observation of this plan is interesting as explanatory of the very small change that has taken place in sinking large masses of ma-sonry to a depth of 21 feet, whilst in the smaller masses, especially in those where there is an aberra-tion to any extent from the per-fect square, the ~~movement~~ movement is more considerable.

The method of undersink-ing is practised by the natives of India (in the North West Provinces especially) to a great extent, it is universally adopted in wells for drinking purposes, and is largely used by their Engineers in obtaining supports for their masonry works, when the soil is either sand or of a treacherous nature, in such cases, cylinders of masonry are sunk either at distances apart or close together, and upon their tops which are arched over and connected by masonry or other bonds, they raise their superstructure. In all the works which I have built on the Eastern Jumna Canal, this system of foundation

had been used with great success, and in the Western Jumna Canal, Colonel Colvin who laid the foundations of the Dadupur Dam had extended the principle by undersinking rectangular masses of the following dimensions 15 x 4 x 10 a good deal of the undersinking being carried through small shingle. Colonel Colvin had with greater or less success also, sunk the piers and abutments of small bridges, which required deep foundations, the whole pier or abutment being undersunk in one mass. The success with which this had been executed, showed that the principle of undersinking might be extended to very large masses of masonry, and in planning the Solani Aqueduct I extended it to cubes of 20 feet, this dimension it will be observed has been increased at the Dunmore works where the maximum horizontal dimension of the blocks is equal to 30' x 30' the depth to which they were sunk being 20 feet. In detailing the progress of the block sinking I shall draw attention to certain laws which appear to guide the proportions of these masses of masonry, but in a general way the difficulties of sinking at all, and the danger of the blocks going down unevenly, increase as the form wanders from that of the square or the circle.

From the ratio of 1/[illegible]

River with which we had to deal, the character of its bed and slopes, and the existence of springs in the surface, it was clear that there was no method of laying the foundations in the usual way by excavation; the alternative lay between the European system of piles, and that adopted by the natives of masonry under-sinking. In my own mind I had no doubt whatever of the relative value of the two, but as opinions were freely given by Civil Engineers whose experience had been derived from European practice, I may be allowed to state my reasons for selecting the native method, in preference to that so much advocated elsewhere.

In the first place in throwing expense overboard, it may be inferred that the use of Piles in the early days of building originated in the impossibility of laying masonry foundations to the depths that could be reached by Piles, and that as this impossibility (even with all our aids from machinery) still exists under circumstances similar to those with which we had to deal at the Solani, the European Engineer still continues to use piles and to depend upon them for the support of his superstructure. I am not aware excepting in cases to which there is no necessity to refer here, as they are clearly except-

involves, that either Engineer or Architect trusts to piles when he can sink his foundations to a sufficient depth, and get the security required without them. With the power then, of undersinking so as to place the masonry in a position which it would naturally have assumed had I been able to excavate, or the purpose, why should I have adopted a method which is clumsy and unsatisfactory? Nobody I imagine can argue that a building supported on a series of hard points, standing on stilts as it were, as is the case where piles are used, can be equal to that where it stands on a broad base as is the result of the block system. On this ground alone I select blocks in preference to piles, and were the method of undersinking comprehended in England, I believe that in fully appreciating its advantages, it would in all sandy and light homogeneous soils be adopted in preference to any other sort of foundation. We see in fact in some bridges lately constructed on the English Railroads, an approach to the principle of undersinking, and a recognition of the advantages to be gained by discarding the common pile. The iron cylinder which is subsequently filled with masonry, and the different inventions to depress hollow masses by atmospheric pressure

are all tending to the right direction, ought to substitute [a] points surface.—

Expense however, is a matter that after all is not to be dealt with lightly.. At the Solani Aqueduct we could only have used the largest species of Timber, sticks that would have had to be brought from the forests in Rohilkund on the left of the Ganges with great difficulty, and at great expense; we should have had to construct very powerful Engines at also a great expense; and we would have had to instruct our labourers in a species of work to which they were in a measure unaccustomed. The piling with its super-gratings would have cost including Engines, repairs and all the different contingencies to which such species of work is liable, at least half as much again as that of the blocks, it would have had in my opinion one solitary advantage only, and that is that the length of pile would have admitted of our getting to a depth 6 feet below that of the blocks.— Whether, in the face of a Torrent where the subsoil of the bed is in motion to considerable depths, and where the evils of percolation and the escape of subsoil are by no means to be left out of consideration, it would have been worth while to go to a

greater

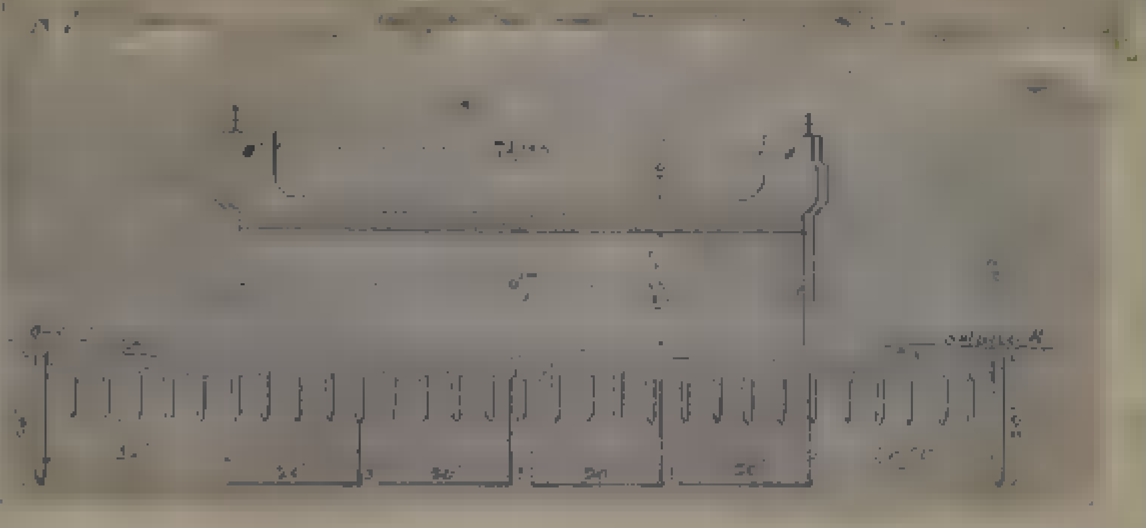
greater expense for a species of foundation most remarkably incapable of offering opposition to these evils, is a question upon which I think there can be no doubt. I have never felt the least distrust as to the selection of the masonry blocks for the foundations of the Aqueduct, nor would I ever think of jarling where such blocks could be used.

Alder

In boring in the bed of the River the depths to which the Irons were carried did not exceed 27 feet, there were no means at hand for prosecuting these enquiries to any great extent, nor did I consider that such were of importance as far as regarded the foundations only. As there was no intention of proceeding to extraordinary depths I considered that soil lying 20 feet below the surface might be depended upon, and that if the subsoil on which the foundations rested was so far protected as to be kept out of the influence of Current action we were as safe at 20 feet as we should have been at much greater depths; with moderate depths of blocks we were moreover, we should be more certain of securing an equability of undersinking. To the depth of 27 feet nothing was found but sand occasionally mixed with clay, but in such small proportions that sand was

was clearly the prevailing in-
-gredient. In practice this
was in a great measure corrob-
-orated, although many of the
blocks have pierced through
and rest upon a soil of a
much firmer consistency than
we met with in the boring op-
-erations. The blocks, however, may
be considered as resting upon
sand, protected both in their
front and rear by curtains
for the purpose of maintaining
the said sand intact and free
from the action of current,
either direct in its progress down
the River, or indirect in its effect
in eddies or movements caused
by obstruction. The design will
be best understood by a diagram
representing the original plan
of 1860.

B.71



The above gives the Aque-
-duct on proportions designed
for a much smaller quantity
of water, but although intended
in breadth to render it capable
[illegible]
[illegible]
[illegible]
[illegible]

and rear are covered by sheet piling with a masonry apron projected to a distance of 30 feet beyond the body of the superstructure. It was supposed that all action of the current would be limited to the extreme boundaries marked by sheet piling. The after improvement of substituting blocks for these lines of piling has still further increased the value of these protective curtains, and causes, which will be hereafter explained, have led to further modifications by which the action of the current is removed to a still greater distance from the body of the work. It will be comprehended by looking at the superficial area on which the base of each of the blocks, on which the main building rests, extends; how much this adds to the stability of the foundations.

I now come to the practical method of undersinking the masses of masonry which form the supports of our Aqueduct. As in the common cylindrical well, a wooden curb/framework or frame is placed in the position in which the block is to be sunk; the masonry is then either built up to its full height or only partly built; it is then permitted to stand over for induration. In my original design each of the curbs was perforated by 16 cylindrical holes,

a

[illegible] was
altered to square or octagon
ones, as giving more space for
the unloading apparatus
between, and being more
economical in construction. –
A common trestle for slag
were placed on each [illegible],
the coal is then instantaneously
removed by means of the Chain
[illegible] a large drum [illegible]
properly [illegible] a Drum,
[illegible] the
[illegible] of
[illegible] when the
[illegible] water, [illegible]
[illegible] is attained [illegible] the
end of the trestle is [illegible]
up, and the coal [illegible]
the Drum [illegible]
out and removed. Trussed con-
[illegible] used
in a [illegible] of these [illegible] as
in the first place we undoubtedly
have collected a sufficient num-
ber [illegible], it was found
that the system which we adopted
was so entirely [illegible], that it
was as easy to instruct the com-
mon labourers of the country
to work the Drums and [illegible]
[illegible] the [illegible], as it would
have been to teach through the
[illegible] of the [illegible]
[illegible]. The trestle does not
[illegible], but [illegible]
the top [illegible] fixed in
[illegible] attached
[illegible] the [illegible]. The
[illegible] the weight
of [illegible] materials,

by means of an descent to the last eight feet, during the depression of the masonry, is sacrificed; whereas on the contrary, in using the diamond [illegible] the [illegible] is brought to bear upon the mass, with at the same time a more economical application of the power. The [illegible] that was used in the [illegible] tools, was a socket attached to the handle end of the blade, which [illegible] the [illegible] by the aid of which we were enabled to sink the [illegible] to a depth of 8 feet without the assistance of divers, [illegible] actually in contact with the stream. I designed the [illegible] after much [illegible] and a great deal of tedious [illegible] of the weather [illegible] previously to my return from England in [illegible]. To this tedious [illegible] the [illegible] at which the masonry [illegible] of the [illegible] cylinders [illegible] is undoubtedly due, and [illegible] that Lieutenant Gale of the Engineers, and Mr. Scott who was afterwards employed with [illegible] at the [illegible] Government works, [illegible] indebted for results which have [illegible] most satisfactory. The way of [illegible] the blocks will be [illegible] better understood by referring to Plate XXVII [illegible] of the Atlas [illegible]

when the work is then in progress, and where the details of construction of the brick laying is also exhibited.

With the removal of the soil from the interior the depression of the block proceeds; it is necessary that this should be uniform, and for this purpose great attention is required in seeing that the holes are equally worked, and that more soil is not taken from one hole than from another; where the soil upon which the block rests varies in quality, much judgment is required in working the holes accordingly with any irregularity of depression that may arise from this want of homogeneousness, and as it will be remembered much practice was required before we arrived at the precision to which the latter part of our operations were carried on. In order to the well sinking truly; and plummets were appended to each side of the block, so that a deviation from perpendicular was easily detected. In cases where the two former means above described were inoperative in obtaining the uniform depression, and frequently when the rectangular narrow blocks were undergoing the process of work sinking, when the deviation from the perpendicular

In the dressing [illegible] somewhat [illegible] apparatus similar to that shown in Fig. II. (marked) Plate XXVII was used, [illegible] a [illegible] frame [illegible] with a [illegible] plate [illegible] at its top, was fitted to the block, so as to obtain the most efficient leverage. The [illegible] the plate [illegible] admitted of any amount of load [illegible] so as to reduce the [illegible] to a minimum, or to [illegible] the [illegible] of the block in the direction that was demanded. This machine was of the greatest possible use in the smaller class of blocks, although not required for the larger.

Dawson

The whole of the blocks of which the mass and [illegible] of the building consisted (vide Plate XXVII) [illegible], with exceedingly [illegible] arrangement. The blocks [illegible] it will be observed [illegible] with a few exceptions only, [illegible], the deviations being in the abutments where there are still (although [illegible]) different [illegible] an equilateral form. In this part [illegible] may be said the uniformity and [illegible] was [illegible], they were [illegible] to that [illegible] blocks which were [illegible] to the faces of the front and rear of the aprons as well as to [illegible] which were appended to the wings. The plan (Plate XXVII) [illegible]

[illegible] there was a double dif-
ference in a very prominent
degree. The sinking of these
[illegible] and [illegible] to
the depths that was contem-
plated was in fact, in a great
measure, a failure. —

The blocks to which
these are numbered on the
plan 37. 35. 51. 52. 53. 67 68. 69. 83
84. 85. 99. 100. 101. 115. 116. 117. 131 132
133. 147. 148 149. 163 164. 165. 179. 180.
181. 195. 196 197. 211. 212. 213. 227. 228.
229 243. 244. 245. 259 and 260 in
the up, and 49. 50. 64. 65. 66. 80
81. 82. 96. 97 98. 112. 113. 114. 128. 129
130. 144. 145. 146. 160. 161 162. 176. 177
178. 192. 193. 194. 208. 209. 210. 224.
225 226. 240. 241 242. 256. 257 258
[illegible] and 272 on the down stream
side; their dimensions are

L	B	D
22.6	6'	26'
20.0	6'	26'
15.0	6'	26'

That is to say it was intended
that they should be sunk to
a depth of 26 feet. When the
[illegible] was made on
the undersinking of these blocks
[illegible] was well practised
and our establishment was
fully [illegible] all the
[illegible] requirements for un-
dersinking. The experience
that we had gained in the
equal sided block construction
failed us altogether. Judging
from the appearance [illegible]
[illegible] these blocks when in
the course of undersinking
[illegible] sunk to a depth of from

the Pilot to a lot of drunken men, the block leaning one way or the other, with an occasional deviation (eccentricity) in a block going down head foremost. The position which they assumed however, is well shown in the sketch of plans. Now, independently of the [illegible] of this irregularity of position which deranges the horizontal lines, and in many cases the close contact of the blocks which was one of the most desiderata, we failed in the main object of diffte. which as designed is the purpose of protecting the main body of the building, was indisputable. [illegible] these [illegible] blocks, without any hope of success and at a cost that was frightful, and the impracticability of getting the [illegible] to work at all. [illegible] were [illegible] out of the question, Tom Rogers proposed that [illegible] should be made with blocks having the same area and shape at the top, but being wider at the bottom, making the block in fact like the frustrum of a wedge, two of the sides being perpendicular and parallel to each other, the other two sloping upwards. It was supposed that this breadth of base would claim an equal amount of equilibrium!

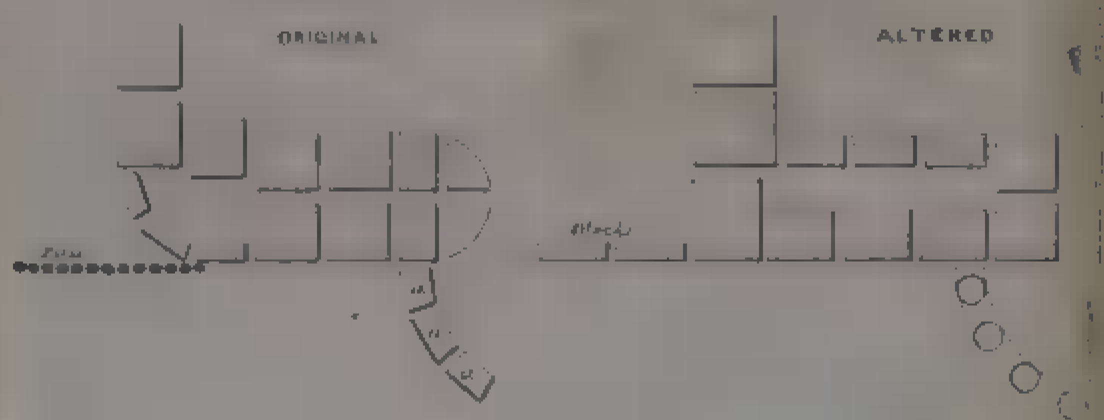
ditions, and that the earth pressing on the sloping sides would by its own gravity facilitate the depression of the block. The experiment was so far successful that all the blocks remaining to be built were constructed on this design and they appear to have been sunk to their full depth, not without all the difficulties and obstructions that attended the rectangular blocks. The plans and sections of the wedge shaped blocks will be found in the plate above referred to.

The result of this failure in the sinking of upper blocks was that the greater portion of them on the right of the river are only sunk to a greater depth than 14 feet, and the depth to which they have been carried is so insignificant that I did not think it wise to place any dependence upon them as the sheet piling, therefore, driven to take the work these blocks were substituted, have been driven both in front and rear, the former at a distance of 15 ft and the latter of 20.5 feet, the intermediate space between the piling and the blocks being filled with boulders loaded with heavy material and weighted on its surface by shingle. The same system of protection [illegible] which has been given to the [illegible]

Bridges, Piers and Abutments in other parts of the works. The foundation of the Aqueduct Bridge, is protected now in a method that was not originally contemplated, but with a view of [illegible] against the [illegible] [illegible] found that it must be considered [illegible] the [illegible] [illegible] advantage.

The foundations of [illegible] [illegible] altered [illegible] with the [illegible] and [illegible] [illegible] [illegible] and the altered design [illegible] [illegible].

Diag CXLIX



The former gave a uniform and equal [illegible] for the super-structure to rest upon. The latter, although it [illegible] the [illegible] [illegible] the [illegible] structure [illegible] [illegible] benefit, and as it [illegible] [illegible] to the difficulties that attended upon the [illegible] of the [illegible] work.

[illegible] [illegible] to substitute for the blocks a a [illegible] cylindrical [illegible]

with a wedge which will [illegible] of the large blocks may possibly have led to an inconvenience which will [illegible]. In description. At a [illegible] rate both these changes from the original design have naturally led to speculations on their particular merits.

In the early operations of Block sinking much care was taken in recording the progress of Block sinking. It was found that on a number of Blocks the average rate of sinking of each description of Block in one day was:-

Size of Block	Rate of Sinking per day Above 10 feet in depth	Below 10 feet in depth
	Running feet	Running feet
16' x 21'	0·789	0·440
14' x 10'	0·784	0·378
20' x 8'	0·623	0·304
20' x 18'	0·784	0·424
20' x 22'	0·679	0·251
26' x 22'	0·638	—

This does not, however, give any correct index to the rate of sinking of Blocks throughout the work as there are many and varying elements affecting both progress and cost.

cost. In Appendix O an interesting paper drawn up by Captain A. G. Goodwyn on this subject, though not entirely complete, shews in considerable detail the operations carried on under his supervision, and with this and Lieutenant Yule's results before me, I find that the average rate for each class of Block sinking over the whole of the work was

Description	Rate per Running foot in depth	
1st Class	16	8 3
2nd Do	16	6 4
3rd Do	9	14 4
4th Do	9	1 6

Every expense being included except that for the Curb frames upon which the Blocks rest.

[illegible] ... was ... [illegible] ... part of the block building ... [illegible] ... addition ... [illegible] ... masonry ... [illegible] ... mortar was ... [illegible] ... quality of the ... [illegible]

method of effecting this opera-
tion is shown in Fig. I. Plate
XXVII together with the other methods
for the support of the blocks by
which the underlying rocks
[illegible] with the soil which [illegible]
[illegible] previously taken from them,
[illegible] [illegible] upon raising the
superstructure upon them.

We will now suppose
that the whole of the blocks are
sunk to the full depth that the
underlying rocks have been
worked out, and that preparations
have now been made for com-
pleting the flooring.

The blocks it will be
seen are [illegible] to the plan
[illegible] previously to the [illegible]
[illegible] in consideration of ground
[illegible] distances apart, so as
to admit of irregularity of de-
pression [illegible] to avoid contact
[illegible] with each other in their
progress downwards, the distance
between the [illegible] of blocks
[illegible] 2.3½ that be-
tween the smaller ones 2'.11" —
The first thing that was done
after a [illegible] was
made to the flooring was to
[illegible] [illegible] so
as to fill up the spaces that
existed between the blocks. This
was done [illegible] the [illegible]
[illegible] so that as far as possible
the [illegible] [illegible] might be
[illegible]. The distance of
[illegible] between these masses
[illegible] [illegible] in the process

of

[illegible] being [illegible] at
a point to what it was origin-
ally designed, and [illegible] the
distance was at this particular
point, [illegible] being driven down
to occupy the whole space. [illegible]
the [illegible]
[illegible] the whole
with [illegible] with a [illegible]
[illegible] masonry [illegible]
the [illegible] were [illegible]
[illegible] to a depth of 3 feet, [illegible]
the spring tide being high [illegible]
[illegible] by [illegible] The [illegible] was
then filled in with rubble ma-
sonry, [illegible] and [illegible]
setting the utmost [illegible]
weight [illegible] the upper
[illegible] was secured with a
[illegible] of rocks and [illegible]
[illegible] that the whole of
this work was [illegible]
[illegible] and the depth [illegible]
by the Assistant Engineer in
charge of the building [illegible]
[illegible] the [illegible]
[illegible] small portions, so as
to [illegible]
[illegible] apparatus, [illegible]
to lay [illegible] masonry [illegible]
-pected [illegible] water, and
consequently, [illegible] the most
perfect work.

Strahan

During the progress of
the [illegible], a work that [illegible]
[illegible] during the season of
1853, a [illegible] was
made to the superstructure. At
this time the [illegible] had nearly
[illegible] made
[illegible] 5½ [illegible], especially those in
the [illegible] abutment, and its
neighbouring [illegible] piers, and it was

on

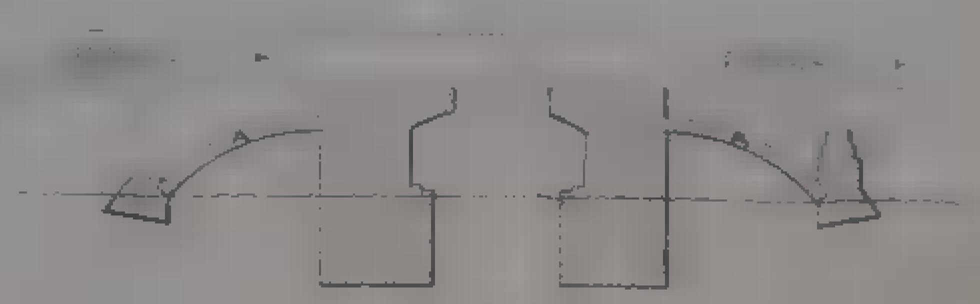
as regards these piers, to commence the superstructure on both sides, gradually working towards the apex, so that the whole of the works might have the advantage of the longest available time for settlement.

At this period I undertook a careful revision of the details of the superstructure as originally designed and taking advantage of the increase that had been given to the width of the abutments, I decreased the rise or versed sine of the segmental arches, making them similar to those which I had elsewhere adopted, viz. 1/6th of a circle, and reduced the thickness of the arches from 8 to 6 feet. This enabled me to give increased waterway & also to raise the springing of the arch to a height of 12½ feet above the bed of the river, a very great advantage to the capacity of the Channel, as well as to the external appearance of the Elevation. The up and down stream ends of the Masonry Aqueduct connecting with the Canal Channel, and the change or transition from the masonry flooring of the one to the earthen flooring of the other, was also at this period a matter of much anxious consideration. Both at the points of ingress and egress of the current upon the floorings, a certain amount of action was certain, and this action would only tend to disarrange the bed in immediate

contact

contact with the abutments, to prevent this they are used to re-move the [illegible] action to a distance, a piece of masonry was placed [illegible] on the land [illegible] so that the water would only act within [illegible] protected limits. The following diagram will show the design of this portion of the work.

Diag: CL



AA being the apron with the [illegible] blocks. That on the upstream side it will be observed has its [illegible] supposed to support [illegible] whilst the down-stream [illegible] is elevated. [illegible] as might be expected at that particular point [illegible] as well as downwards. On the upstream side the water being deflected, a [illegible] was adopted.

[illegible] the middle [illegible] was [illegible] worked out in de-tail and although not ac-tually [illegible] for the imme-diate purpose [illegible] was fitted with [illegible]

of the delivery channels prove the design. I [illegible] also [illegible]
in deciding the highwater mark
left by floods in the Solani, and
at the [illegible], by appear-
ance [illegible] on the [illegible] of the
aqueduct, whilst the [illegible] of
the sides were secured by grand
pedestals, ornamented by lions.

The [illegible] of that part
of the work (with the exception
of the Spandrils being [illegible]
for ventilation) was thus much
the same as it was formerly.

The plan that I originally
adopted of building the Super-
structure in two separate lines,
or of making the channel
[illegible] in two separate
[illegible], was maintained
in the final revision. The total
width of the trough was 164 feet
[illegible] was raised
to [illegible] of 8 feet in width
[illegible] a [illegible]
either side a [illegible] road.
There were sundry advantages
in this plan, the greatest of
which was its admitting of
irregular settlement of the
foundations without disar-
rangement of the whole area of
the superstructure; great facili-
ties were also [illegible] to the con-
struction of the arches as by
the proposed plan, the [illegible]
on which settlement might
be effected on removing the
centres was reduced to one
half; whilst the quantity of
[illegible] and apparatus for build-
ing

ing the Arches was reduced in an equal proportion. In carrying the Channels for the passage of the Canal water a regard was had to convenient means of repair without the necessity of drawing off the Canal. The design was to place [illegible] of the arch in [illegible] perfectly dry, whilst the other affords a free passage to the water. Another consideration that led me to the division of the passage over the Aqueduct into two Channels was the probability that any one extended surface equal to the whole width of the water would be found to exert lateral thrusts which would be injurious to the piers of Aqueduct, inasmuch as a perpendicular pressure on the masonry and a lateral action upon the side walls or channels would might endanger their stability. The intervention of a central wall would in a great measure obviate such an evil by this construction.

It will be observed that at each end of the Aqueduct, the waterway is divided by piers for the reception of stop planks, which are to be dropped through grooves formed for their reception. The opening [illegible] of these Channels, permits the admission of further water, whilst small sluice Gullets connected with drain channels carried through the Abutments towards the [illegible] in the lower ground give facilities for carry-

-ing off the water which remains in the chamber after its ends were closed. The chamber being thus laid dry, any repair required may be easily effected. The piers above described give supports like [illegible] of arches communicating from one side of the Aqueduct to the other, obtained by the slope planks which, when not otherwise required, being thrown open [illegible] to pass.

The spandrils were filled in by cells walls as shown in the plans, pierced by archways, and opened out to the external air by means of the circular holes which appear in the elevation on the Pilasters. These round holes give air ventilation to the whole of the space connected with the spandrils, which by means of the archways above noted, are accessible in all their parts.

The thickness of the masonry between the soffit of the arches and the surface of the flooring of the channel is four feet four inches, under ~~[illegible]~~ the crown of the arch, and thickening ~~[illegible]~~ as it [illegible] flat ends. The level of this flooring coincides with that of the Roorkee bridge, a part of the design which will be [illegible] [illegible] [illegible] the original levels upon which the Aqueduct was designed.

The tops of the side walls, [illegible] which are [illegible] feet in width, are furnished with double lines of railway in connection with those which

extend

ated along the Embankments. The sides of this Aqueduct and roadway are protected by Iron balustrades.

The above with the Atlas plans will enable the reader to obtain a fair estimate of the design as it existed at the point when the superstructure was commenced. I shall now proceed to give an outline of progress during its construction.

On the completion of the piers to the full height including the Key-backs or imposts above, on which the arrangement to rest the single line of railway which I have described and figured in Plate CXXXVIII as running from the Portion brickfield to the Bridge and [illegible] inclined plane to the level of the top of the culverts, had been gradually, and as the masonry had advanced to a sufficient height, pushed across the Plain, to meet a similar line which had been made branching off from the double rail on the Nubanai Side. The completion to regions of the upstream culverts, and, consequently, the line of single railway gave us a connecting link between the brick fields at the extreme ends of the Aqueduct works, and enabled us to concentrate all our selected material for arch building on the field of our operations. The railway to which I am now

alluding

abutting, as connected with the
tops of the up stream cutwaters,
was carried across the 50 feet
bays by the interposition of
two temporary piers in each bay,
the width of each being 3 feet and
its height 10 feet. Each 50 feet
opening thus, was divided
into 3 bays of 13.66 feet in width
each. The rail was supported
on timbers of 12 inches square,
or of the common size brought
from the yards, laid longitudinally
across the pier heads. There was
by this arrangement a [illegible] al-
though somewhat interrupted
[illegible] on the [illegible] along
the whole line of the work.

^ The material for each
Arch was collected immediately
on the spot where it was required,
it was deposited on platforms
arranged for the reception on
a level with the rail way, as
well as on the tops of the piers
[illegible]. The bricks were of
the best sort procurable, of
[illegible] manufacture, they
had been in progress of selection
from the early periods of our
brickmaking, and although
many of them required cutting
and squaring to adapt them
to the particular purpose for
which they were intended, they
were without doubt of a first
rate quality.

Before proceeding to a
description of the Arches, and
their centering, I shall take the
opportunity of detailing events
which had occurred at this
period

period of the progress of the work, that is to say, from the commencement at Bhukshinking up to the 1st of December 1847, or the date when the first brick was laid in the works.

Withdrawn

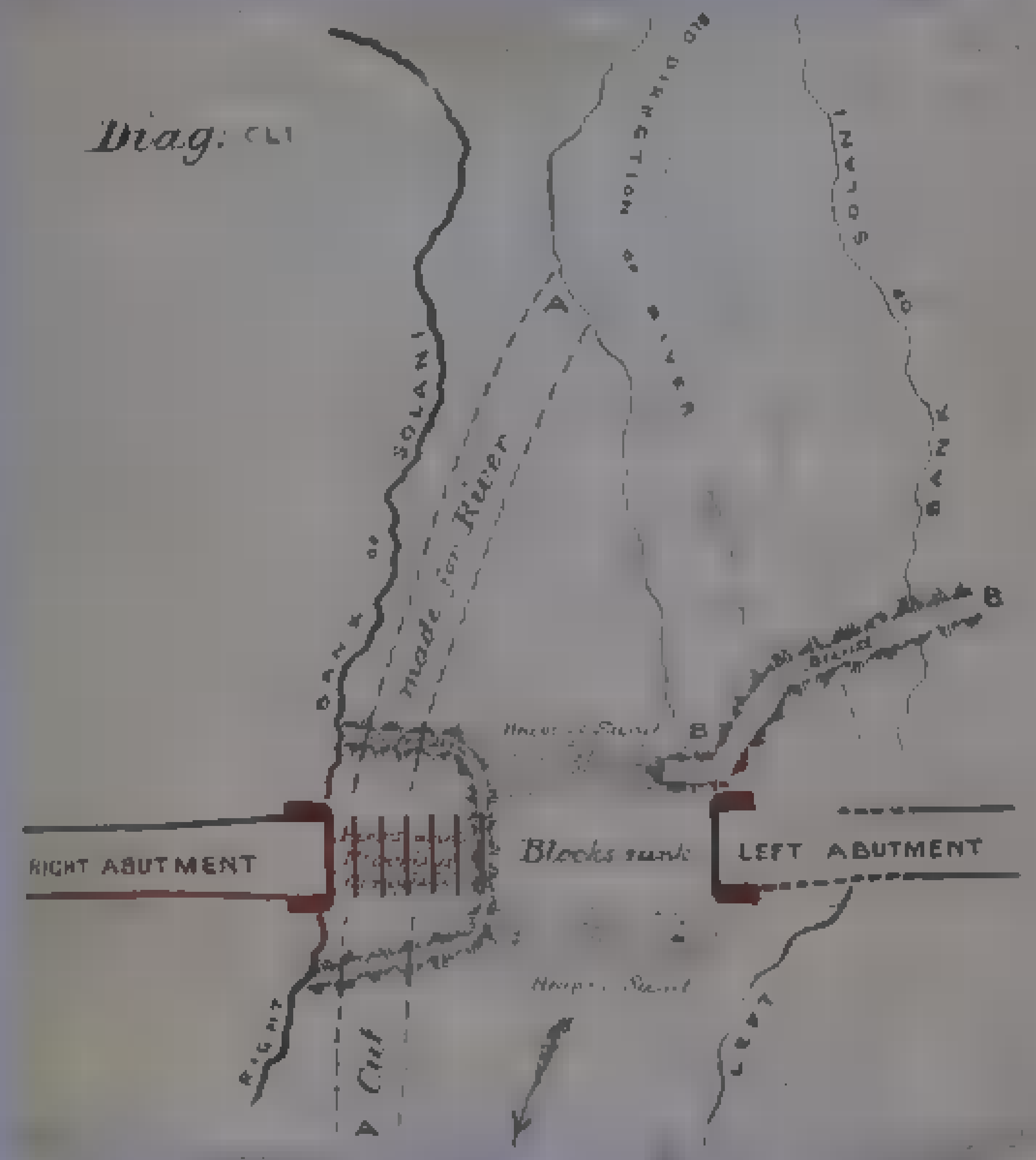
In January 1848, when I rejoined the works, a cofferdam or Embankment had been thrown round the whole of the works which were in progress. This cofferdam included the great [illegible] and its neighbouring piers, and it was under the protection offered by this enclosure that the work was continued through the rains of 1848, and partly through those of the following year. When the rains of 1850 were approaching, the progress that had been made on both flanks in the raising of the abutments and in part in connecting them with the Earthen Aqueduct Revetment made it necessary that we should endeavour to restrict the torrent to a course bounded by the abutments. There were no difficulties opposed to the measure, and the only danger that was incurred was from the unfinished state of the Earthen [illegible], which at that period was [illegible] incomplete and in such a state that I considered it necessary to protect it from the torrent and from the water [illegible] in its passage down the [illegible].

At the commencement of the Rains of 1850, the state

of

In describing the Aqueduct, it may be useful to note that I use the terms 'Right' and 'Left' with reference to the course of the Solani River.

This [illegible] will be understood from the following diagram, in which are noted the banks and cuts which were made, [illegible] to the rains of that year, for the purpose of protecting the left flank and abutment, and of making the River clear among the coffer-dams, as well as the mountains [illegible] that [illegible] during the progress of block sinking.



The course of the [illegible] will be observed both from the above diagram and from the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

in cut AA bearing upon the
right flank, and passing the
coffer dam on both sides. The
height of [illegible] a figure a above
which the coffer dam and the
left abutment were cased off
so as to give passage to the
water, and the left abutment
built with its half finished
brickwork (which are shown
by ~~[illegible]~~ thick dots), was covered by a
strongly built embankment
and spur. As this was the
first year that the river had
been called upon to pass through
an artificial boundary, its
conduct (taking every thing
into consideration) was not so
capricious as it might have
been. On the 8th August 18[illegible]
in reporting the effects of the
floods upon the Ganges Canal
works, I observed that the re-
-sults of the floods at the S[illegible]
[illegible] River have been of an
exciting interest. "Both the
abutments of the Aqueduct,
through which the passage
of the River had been effected,
had been completed to a suf-
-ficient height, and although
the embankments on the right
and left were not entirely
finished at the commencement
of the rains of 18[illegible], the bank
[illegible] and other protection
works were so arranged, that
the whole of the floods might
pass through the water ways
of the masonry work.

"A coffer dam had
been thrown round the Six

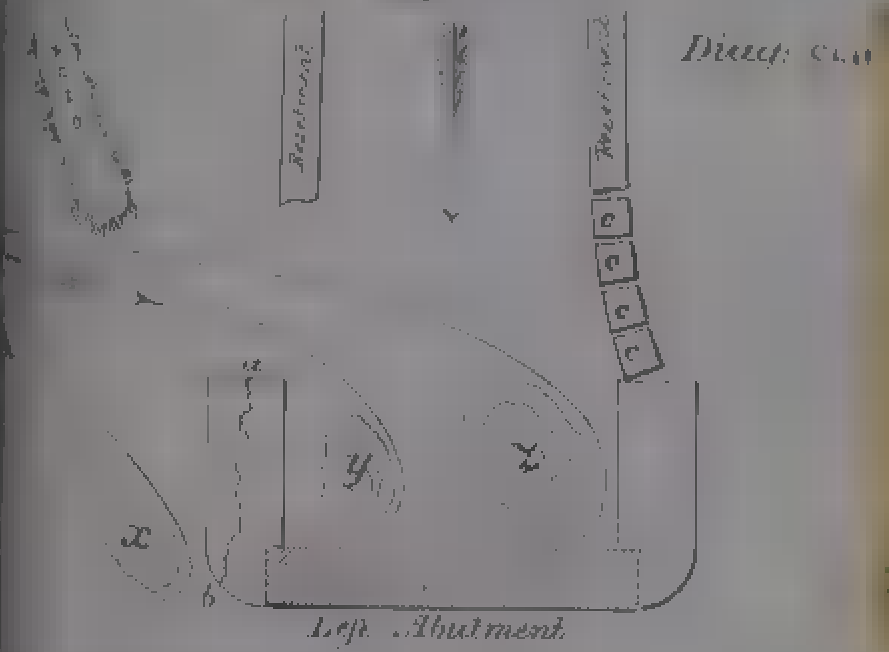
[illegible]

openings and piers on the right bank so that during the rainy seasons previous to 1880, work might be carried on independently of floods. The object now was to get rid of this coffer dam as well as of the mountains of sand that had been collected from the widening and excavation for the masonry foundation of locks. It was determined therefore, that the early floods of 1881 should be the power ~~[illegible]~~ employed for obtaining this very desirable result, and the Executive Engineer's attention was directed to such [illegible] as would lead the water through a channel prepared for its reception across the coffer dam and impinging on the right abutment of the work: it was also determined that the main body of the floods should be confined to half the full extent of the water way, or to 7 of the bays or openings of 80 feet in width each as shown by the above diagram."

In the ~~[illegible]~~ same report [illegible] state th[illegible] the above works have been most successful; enormous quantities of the collected rubbish have been swept away, and the whole river now instead of having its old course upon, or rather through the left abutment, passes over the site of the coffer dam, and through the piers which on this side have

been

... that in this the left side ... conduct, rather flowing ... blocks have been ... so that the current with ... was able to exert its full ... the absence of connecting ... the Revetment to the ... flank, permitted the ... to get behind the Abutment, ... that I had tried to pre... nevertheless, taking everything ... consideration, the damage ... less than might have ... expected." The following ... shows the discharge ... and its method ... when it came in contact ... the masonry.



Left Abutment.

... Holes excavated by the Current
... Blocks remaining uninjured.
... Cur... ... the Wing.

... portion ... of the Abutment ... is ... with the ... ... of the building ... The breach was dependent ... excavation x, and the ... of the wall from the ... was 1'.5 inches ... maximum point. ... considered necessary ... the building which ... been ... ... but the ...

[illegible] completed. The [illegible]
[illegible] was [illegible] [illegible]
that during the time [illegible]
floods which effected this [illegible]
were running and [illegible]
water was confined to 3 [illegible]
there was as much as 1' [illegible]
of fall on the length of the [illegible]
(16 feet) but as the [illegible]
of [illegible] gradually diminished
it became level. The water
on the piers to a height of [illegible]
[illegible] above the [illegible]
over the sides in a heavy [illegible]
Subsequent to the date [illegible]
[illegible] to, and during the [illegible]
of August 1860, a [illegible]
flood, gave some trouble [illegible]
Embankment on the [illegible]
BB Diagram CLI, was washed
away, and the water [illegible]
a [illegible] of the abutment [illegible]
amongst the unfinished [illegible]
half sunken blocks of [illegible]
[illegible], and some damage
caused a slight settling [illegible]
the leg upstream [illegible] of the
Abutment. In reference [illegible]
effects of these floods [illegible]
that is the blocks which [illegible]
been disarranged, and the
settlement that has taken
place on the superstructure
[illegible] independent [illegible]
of the Aqueduct and of the
Abutment upon which the
Arches will rest, they [illegible]
is of no consequence to the
work, although additional
outlay will be required [illegible]
[illegible] matters [illegible]
condition [illegible]

hole excavated at it was filled in with heavy material, and strengthened by piling, and all other means were taken to remedy the defect as well as to prevent any further continuation of settlement. The rains which usually terminate in September did no further damage. The good that they had done on the opposite bank in clearing away the Coffer dam, and in removing the sand was incalculable. On the whole and considering the extent of the floods during 1850, we escaped with very moderate injury.

The cold weather rains of 1850/51 were unusually severe, but the floods that came down the river at this period passed off without any damage worthy of notice.

The rains of 1851 brought down numerous floods, and tried the Aqueduct at a period when the Vaults, the intermediate piers, and the greater part of the flooring were completed. From this year may be dated the passage of the Potomac through the [illegible] Aqueduct, and when the Masonry works in connection with the Tunnel were prepared for its reception. The maximum high water during the heaviest flood of this year stood [illegible] feet water, and this season passed without any disarrangement to the works.

C.

On the 1st of December 1851, the building of the Arches commenced, and they were carried on without interruption until the 1st of July 1853 when the last arch was keyed.

It was my intention at the period when the Aqueduct was designed, to have used [illegible] Centerings, which have the merit of cheapness and simplicity, combined with other attributes, which in my idea rendered their use at this point very desirable. The results however, of using Centerings of this description on the line of Canal below Rochester in building Arches of 55 feet of span, were decidedly opposed to their introduction on the Aqueduct where, although the span was less in width, the thickness and consequent weight of the arch was greater. I have in the chapter on bridges when describing the different species of centerings which have been used on the works, entered fully into the causes which led me to reject these simple Centerings at the [illegible] Aqueduct; and [illegible] altogether in devising any satisfactory expedient by which I might preserve the form of the Arch, and at the same time escape from a direct rigidity of centering, I determined on resorting to the European method of Timber ribs, and with the [illegible] Capstan [illegible] of the

the Engineers, the Executive En-
-gineer at Roorkee, commenced
a series of experiments, for the
purpose of determining the
best sort of frame that could
be made, at the smallest cost,
and with the least injury to
the timber that it would be
necessary to cut up for the
purpose. It was our object
as far as possible to take ad-
-vantage of the species of sawn
up wood that was for sale in
the market, and at the same
time that we secured efficiency
to obtain a species of centering
that would interfere as little
as possible with the waterway,
and be quickly and easily
removed. –

Hull

The results of Captain
Cordery's experiments led to
the adoption [of a species of
centerings which I shall des=
cribe presently, and to a method
of limiting their number, by
building the arches in detail,
which both as regards economy
in the construction of the work,
and convenience for passing

Int

off floods during the opera-
-tions,] was of the greatest value.
The plan that Capt. Cordery
proposed was, that by construct-
-ing certain bays into abut-
-ments the arches might be
turned in a series of inde-
-pendent works, for which only
a limited number of centerings
would be required. By adopting
this method, we should be
able to have $\frac{3}{5}$ths of the bays,

of the Aqueduct always open for the passage of floods, and by confining our arch work within moderate limits, we should be better able to economise our men and our material - The proposition was an excellent one, and it has been adopted with all the success that could have been anticipated - The arch building, as will be understood by the following diagram, consisted of eight independent series of triple arches, resting on temporary abutments formed by building walls across the bay adapted to the ultimate support of the centerings, the spaces between the cross walls being filled in with sand.

Diag. CLIII

It will be observed by the above diagram that by the arrangement above mentioned, each series is conducted independently of its neighbour from the circumstance of the arch [illegible] on its full width of 193 feet being divided into separate portions of 96 feet each,

to

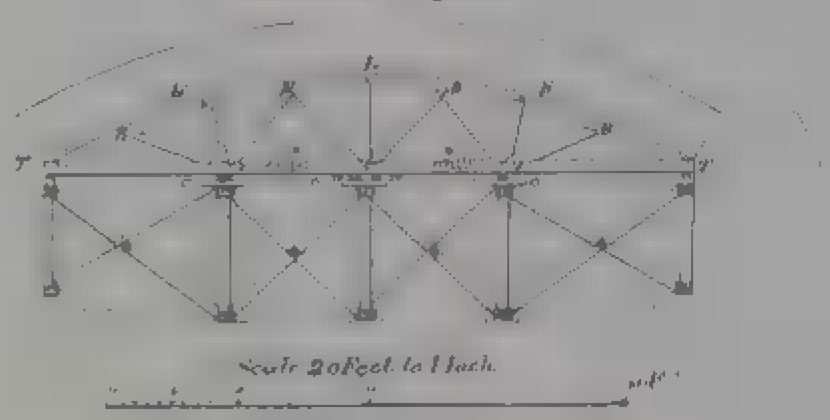
Diag. CLIV

SOLANI AQUEDUCT

CENTRES

Fig. 1

End Elevation of Centres



Scale 20 Feet to 1 Inch

Fig. 2

Elevation Showing method of moving Supports of ribs

Scale 10 Feet to 1 Inch

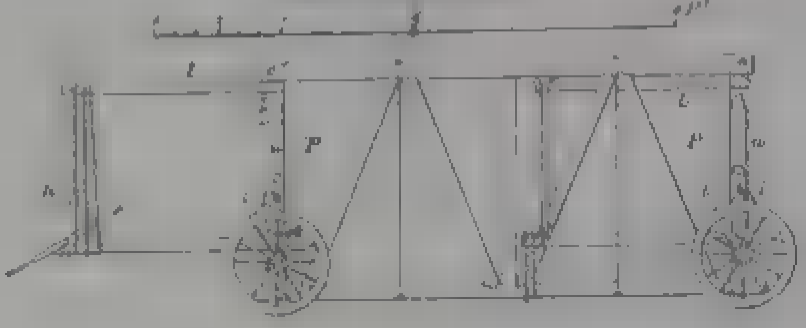
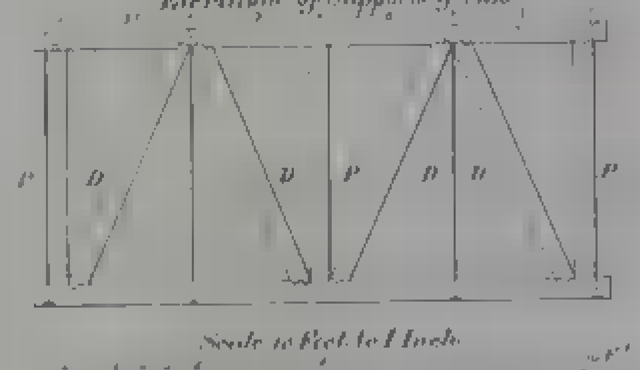


Fig. 3

Elevation of Supports of ribs



Scale 10 Feet to 1 Inch

the work to be resolved itself into an up stream and a down stream line constituting two sets of arches, or 8 independent series of works: I was of the [illegible], therefore, that the building of the arches was to proceed 9 out of the 16 bays, giving a clear waterway of 450 feet in width, might always be open to receive floods."

The construction of the arches in the order above noted, commencing on the right down stream side was dependent on facilities for obtaining materials which that place presented, [illegible] the other which was [illegible] [illegible], commencing each bay on the [illegible] [illegible] the plan adopted also gave us at an earlier period a communication across the Aqueduct.

The whole arrangement having been determined on, the quantity of woodwork required was limited to that for 8 bays, each of which was 50 feet in width and 90 feet long. Captain Goodwyn in making his report to me on the conclusion of his experiments, and after having put his centerings to practical test, writes thus:

"As it had been decided that the Aqueduct should be arched from shore to shore by [illegible] eight arches of 50 feet each, the distance at which the ribs of the centering should stand from each other was regulated

by

of the scantling of the Burgari "Kurri" wood, for the support of an arch 1½ feet thick, permitted those ribs to be distant from each other 5 feet from Centre to Centre, without itself suffering appreciable deflection.

"In designing the ribs having in view the expressed wish of the Director of the Works to have it fully conveyed, that the arches should be struck immediately on the arches being keyed, and whilst the masonry was as fresh as possible, a continuous tie beam TT Fig 1 the upper surface of which represented the springing of the arches, appeared to afford greater facilities for regulating the striking, as well as the adjustment of the centres in removing the Archwork, than supporting the bearing pieces BB direct from the flooring. To make a tie beam 56 feet in length, however, two scarfs SS were indispensable owing to the short length of timber available, and this with the advantage of giving the beams BB as many trussed points as possible, thereby stiffening the framing and rendering timber of comparatively small scantlings available, induced me to give the tie beams five points of support, as the most economical arrangement.

Having these fixed points T t t' t

T t t' to T, on such intermedi-
ate fixed points BBBB immediately
resulted; and the lower surface of
the piece BBBB was divided into 3
radial bearings. — This arrangement
K & C gave the drawing in the ma-
chine supports of the beams,
and since there is a bisected
the lower surface of the beam
[illegible] the points t t where
the supports from the frame
would be most advantageously
applied.

"The arches are the same
to be well designed which is
subject to a line of thrust
without being loaded. Had TKL
been in the form the result of
the arch tending to press
from the sides of the arch towards
the centre, and opposed K would
have raised up the arch L above
its giving the desired degree
of [illegible] to the [illegible] of the
arch. The pieces BB were longer
connected at K though touching
at L a space of 3 inches was left
between the beams, thereby allowing
the beam T t' T to be deflected
without producing the [illegible] in the
arches, the points TT were [illegible]
fixed, without the [illegible] of the
arches BB coming in contact at
L. It was not supposed that
the beam would sink as much
as [illegible] inches on the [illegible] being
struck, and the arch [illegible]
[illegible] and [illegible] for
[illegible] been required it
would have been [illegible] after
removing the points T [illegible]
[illegible] supported by wedges with
this [illegible].

"The supports of the points T t t' t T are shown in Fig. II. They consist of rough beams dressed on two of their surfaces parallel to each other, and of such lengths between the limits of 24 and 48 feet as our stock afforded. These parallel beams were united in trapezoidal [illegible] PPP of strength calculated sufficient to resist the downward pressure at the points T t o a t', and the intermediate points between PPP (K. K. 497 [illegible]) [illegible] by the diagonal beams D, each piece of timber was of the same [illegible] strength as the vertical planks P. The whole frame was then bolted together [illegible] the suspension rods as shown by the dotted lines [illegible] support.

"Stout [illegible] beams are [illegible] at each [illegible] width of [illegible] measures, but naturally [illegible] after the beams [illegible] put together, and are [illegible] the vertical position by a simple contrivance [illegible].

"[illegible] with axles and [illegible] with upright pieces of timber (Fig. III) [illegible] on the axles [illegible] these uprights are kept in position by wooden braces [illegible] b, the [illegible] and [illegible]

the poles. The poles were kept rigid in an horizontal direction at the point of attach[illegible] and to the axle tree by diagonal wrought iron braces at the opposite right angles formed by the crossing of the Poles with the axle tree, by having room for the runners to be hooked or drawn close up to the wheels, which if diagonal braces were used could not be done. The adaptation of braces on the tops of the uprights u will be understood by inspection of the Diagram Fig. III.

"When it is desired to raise the frames which it would be re[illegible] [illegible] have been left in a P vertical position after the removal of the Curved ribs, the braces l [illegible] by means of the [illegible], and the end bolts [illegible] the same as the leading carriage, [illegible] [illegible] of the frames P by the carriages being backed. The upright posts u having been bolted in contact with the end pieces P of the frames, the [illegible] drawn, and the frame is lifted from the [illegible] ground and [illegible] suspended from a [illegible] at the end of the line [illegible] which being [illegible]. The uprights u and the [illegible] to the frames P (the [illegible] having been previously [illegible] as shown in the Diagram [illegible] and the machine is ready for transit. In the [illegible] carriage, it is evident that the end of the [illegible] [illegible]

end of the [illegible] e, [illegible] ought not to use a crowbar at right angles to the [illegible] giving a cross [illegible].

"The [illegible] with [illegible] [illegible] together and act like the [illegible] of a carriage [illegible] of the [illegible] can be [illegible] [illegible] [illegible] to be kept [illegible] as all are [illegible], and the whole [illegible] over the masonry [illegible] of the Aqueduct with great ease, carrying its load in a vertical position, and depositing it in the same position on its [illegible], after which it is [illegible] by [illegible] [illegible] [illegible] across each other [illegible] diagonal [illegible], and [illegible] at their centres.

"Above these [illegible] [illegible] thus [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 3' × 1' × 3" [illegible] [illegible] [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to clear the [illegible] [illegible] [illegible] is [illegible], and [illegible] [illegible] [illegible] [illegible] [illegible] with a [illegible] of 3' [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ww sufficiently distant from each other to admit the [illegible] [illegible] [illegible] [illegible] necessary, [illegible] [illegible] upon the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], and [illegible] preserved [illegible] injury by [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] on the lateral [illegible] t t

[illegible]

[illegible]owever, from damage; and the
lifting, and as the weight borne
by them is very considerable,
the projection of the piers c c on
each side is valuable as af-
fording the means of applying
as many pairs of wedges as
may be required; thus dimin-
ishing further on each wedge
the risk of difficulty [illegible]
[illegible] especially
when the wedges are [illegible]

Burroughs

Upon the completion of
the masonry the arches are
[illegible]
[illegible]
[illegible] until the blocks were
[illegible] A double
kind of guard [illegible] to
each of the points [illegible] and [illegible]
and the operation of [illegible]
is then commenced. [illegible]
[illegible] points [illegible] adjacent [illegible]
[illegible]
[illegible] 15 [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] end of [illegible]
[illegible]
[illegible] 12 [illegible]
[illegible]
[illegible]
[illegible]
[illegible] that would result in a
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] they had [illegible]
[illegible]

[illegible] of ropes, [illegible] which was a question of time."

I have proposed an introduction of Capt. [illegible] own account of the present; it was so used as far as with the appended drawings nothing will be left for further explanation; the modifications that experience showed to be necessary were unfortunately trifling, and hardly worthy of record. It will [illegible] the tabulated dates at which the sledges were begun and completed, that practice [illegible] the transportation of the [illegible] from one place to another, their fixing and preparation for the [illegible] [illegible] for a speedy operation.

[illegible] dates at which the Arctic appliances to the different sledges [illegible] CLIII were commenced and completed			
No. of Sledge	Date of Commenced	Date of Completion	Number of days occupied in their construction
1	1st Dec. 1852	21st Dec. 1852	21
2	[illegible] 1853	24th [illegible] 1853	21
3	12th April "	30th April "	19
4	[illegible] June "	11th July "	23
5	13th [illegible] "	[illegible] 1853	21
6	21st [illegible] 1853	10th [illegible] "	15
7	13th April "	30th April "	18
8	21st May "	5th June "	16
[illegible] Boats			
4	17th [illegible] 1852	[illegible] June 1852	16
3	do	do	16
12	21 July "	9th Aug. "	[illegible]
[illegible]	15th June 1853	4th July 1853	20
[illegible]	do	do	20
[illegible]	do	do	20

Although very great [illegible] [illegible] that favoured the separation of the [illegible] at the [illegible] [illegible]

[illegible] frequently [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
had been used [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible], [illegible] [illegible]
[illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
part of the [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] described
as [illegible] [illegible] [illegible]
the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] that
[illegible] [illegible] [illegible]
"[illegible] [illegible] the [illegible]
"[illegible] [illegible] [illegible]
"[illegible], [illegible] the [illegible], [illegible]
"[illegible] [illegible] [illegible] [illegible]
"[illegible] [illegible] the [illegible]
"[illegible] [illegible] about [illegible]
"the [illegible] [illegible]. [illegible]
[illegible] [illegible] [illegible], and
must [illegible] [illegible] [illegible]
from the [illegible] [illegible]
[illegible] [illegible] the [illegible]
[illegible] that the [illegible] [illegible]
[illegible] [illegible], [illegible] [illegible]
[illegible] [illegible] [illegible], [illegible]
[illegible], although [illegible]
[illegible] [illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] the [illegible]
[illegible] of [illegible] it was [illegible]
[illegible], the [illegible] [illegible]
[illegible] be recognized [illegible] [illegible]
[illegible] [illegible]. [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] the [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
and [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] above, and [illegible]
[illegible] [illegible], [illegible] by [illegible]
[illegible]

arranging to select the method by which the material of the arch in its own state might settle down uniformly, without concentrating action on any particular point. The results of this appear to be that ~~[illegible]~~ from [illegible] evidence ~~[illegible]~~ experience furnishes [illegible] [illegible] that these [illegible] separations are almost inevitable in arches ~~constructed~~ built ~~[illegible]~~ centerings composed of materials which are compressible by the weight of the arch prior to the keying.

~~[illegible]~~

[illegible] [illegible] that was adopted [illegible] was the same as that [illegible] [illegible] to the [illegible] in Bridge [illegible] [illegible] in Plate CXII.

For the [illegible], as [illegible] [illegible], the best [illegible] of [illegible] ~~[illegible]~~ was procurable from the [illegible] [illegible] [illegible] [illegible], selected for the special purpose, and [illegible] [illegible] sand [illegible], was used. The brickwork was carried on with the greatest possible care under the constant superintendence of Mr. George [illegible] the [illegible] [illegible]; [illegible] [illegible] [illegible] was at [illegible] [illegible] [illegible] [illegible] [illegible] at [illegible] time, and the smallest possible quantity of mortar was used. [illegible] [illegible] which was commenced [illegible] [illegible] [illegible] towards the crown, was completed to within 2 courses of the keying; [illegible] [illegible] [illegible] [illegible] [illegible] the introduction [illegible] [illegible] of [illegible], [illegible] the masonry [illegible] [illegible] [illegible] [illegible] [illegible] lightened [illegible] [illegible] [illegible], the

Keying

[illegible] the upper [illegible]
with the [illegible] drawn
[illegible] tablets.

[illegible] early on the [illegible] after the [illegible] was [illegible] immediately the [illegible] was [illegible] 7 [illegible] days afterwards, and [illegible] was [illegible] and its [illegible] (Diagram P) [illegible] preceding [illegible] of the Diagram [illegible] determined [illegible]

[illegible] that the [illegible] removal of the [illegible] the different [illegible].

[illegible]	[illegible]	
	Bo[illegible]	[illegible]
	feet	feet
1	0·1005	0·1905
2	0·0[illegible]	0·19[illegible]0
3	0·16[illegible]5	0·[illegible]710
4	0·0932	0·1785
5	0·1135	0·1650
6	0·1552	0·2475
[illegible]	0·2115	0·3180
[illegible]	0·0065	0·1650
9	0·0870	0·1445
10	0·0895	0·1895
11	0·1029	0·1985
12	0·0760	0·1290
13	0·0502	0·1200
14	0·0765	0·1419
15	0·0532	0·1530
16	0·0990	0·1875
17	0·0880	0·1975
18	0·1060	0·2305
19	0·0332	0·1325
20	0·0265	0·1135
21	0·0272	0·1155
22	0·0457	0·1355
[illegible]	0·0873	0·1509
[illegible]	0·0897	0·1460
[illegible]	0·0620	0·1060
26	0·1057	0·1703
[illegible]	0·0620	0·1340
[illegible]	0·0790	0·1550
[illegible]	0·0611	0·1335
30	0·0485	0·1305

The quarries were not allowed to be touched by [illegible] until a period of 6 months had elapsed from the date of [illegible] [illegible].

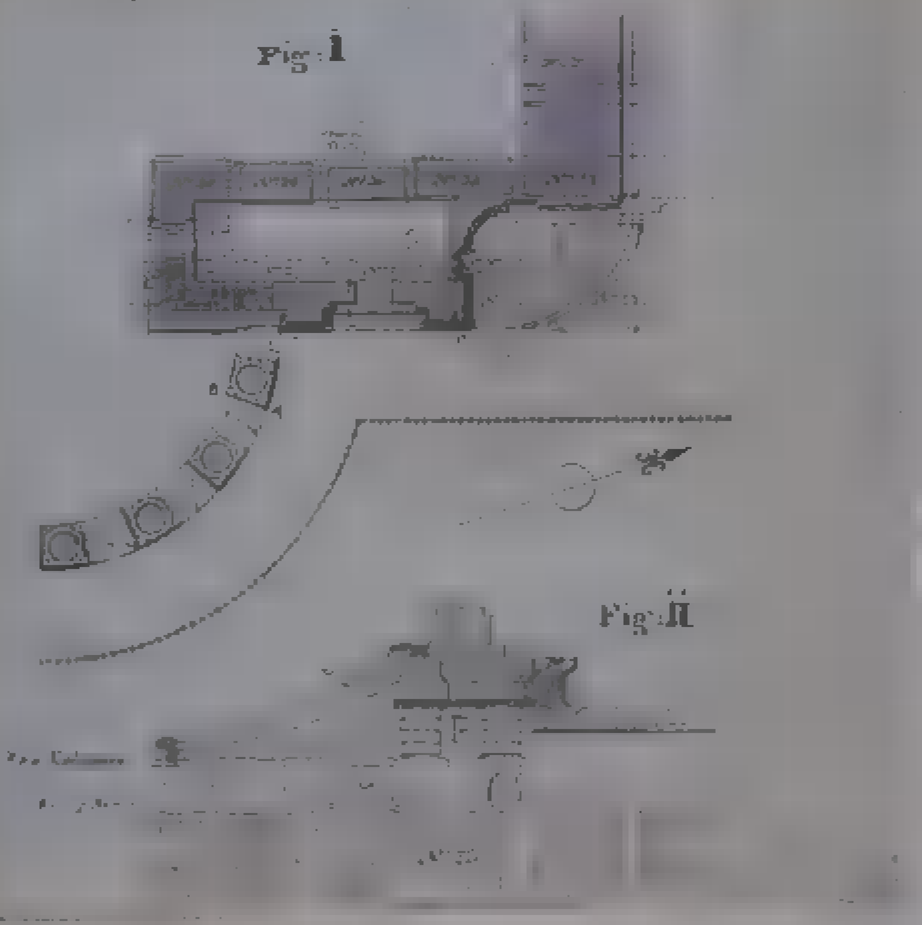
During the construction [illegible] [illegible] [illegible] [illegible] from Clear: CLIII was [illegible] progressively from [illegible] 3C. [illegible] [illegible] with [illegible] [illegible] advanced with a good [illegible] of progression [illegible] [illegible] [illegible] [illegible] [illegible]. Immediately the [illegible] was completed across the [illegible] from [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] from [illegible] on the north and from [illegible] on the south [illegible] connected by a [illegible] from the [illegible]. At this period [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and the [illegible] [illegible] [illegible], to [illegible] of materials.

The probability [illegible] [illegible]

-ment occurring during the raising of the superstructure was naturally a circumstance of considerable anxiety. On such an extended area of foundations, connected with soils of various descriptions, it was hardly to be expected that we should entirely escape from a contingency which although not likely to be of serious importance, might lead to derangements even during the progress of construction. [illegible]

[illegible] Diagram CLIII [illegible]

Diag: CLV



[illegible] taken [illegible] the [illegible] the [illegible] structure [illegible] the [illegible]. Beyond the porch [illegible] the [illegible], the [illegible] [illegible] the [illegible] represented in Fig: II. At the [illegible] Fig: II. the [illegible] the [illegible] immediate [illegible] with the [illegible] that

led

inclined to agree that the whole pond [illegible] together with the Quadrant [illegible] had slightly settled [illegible] that we say that the [illegible] [illegible] [illegible] has separated itself [illegible] the [illegible] of the Aqueduct. It appears to me that the Works [illegible] 24 and 23 [illegible] settled down towards the [illegible] as the frames [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] settlement of [illegible] was [illegible] considerably slight that the [illegible] of the [illegible] was [illegible] [illegible] to detect [illegible] [illegible] the [illegible] [illegible] of the [illegible] [illegible] [illegible] raised [illegible] me [illegible] to the conclusion that the settlement had taken place on the side towards the [illegible] of the building [illegible] Works [illegible] 23 and 25 [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the building [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible] [illegible] to the settlement.

Stratham

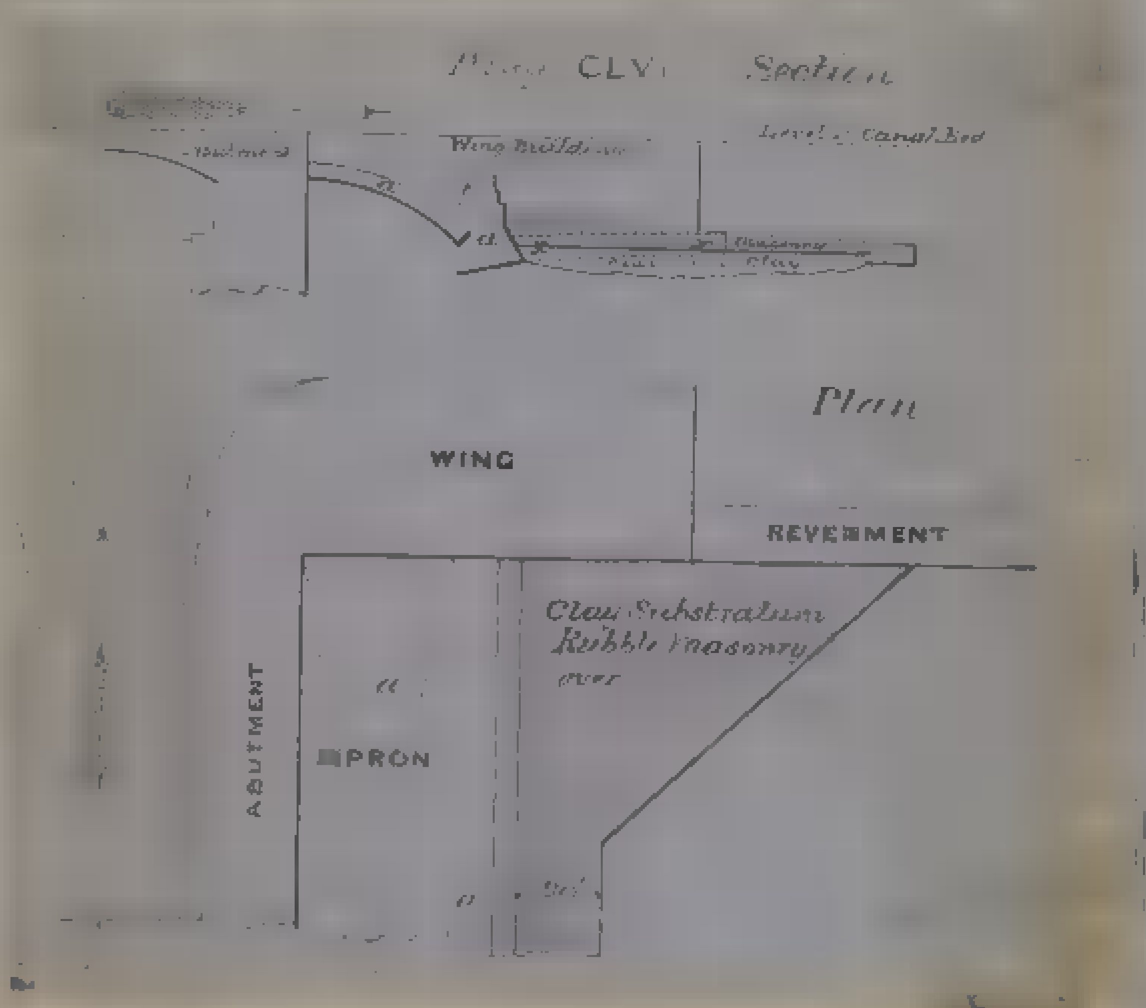
The Quadrant wall [illegible] [illegible] were [illegible] designed [illegible] [illegible] [illegible] to [illegible] [illegible] the Aqueduct [illegible] to adopt [illegible] [illegible] [illegible] [illegible] Quadrant [illegible] [illegible] [illegible] [illegible] the superintendent [illegible] [illegible] [illegible] [illegible] [illegible] the vertical pile.

-dius critical portion of the masonry forming the segment of a circle between the two, tangential to two wells, is thrown out, falls beyond the foundations. Whether this can be admitted as an end sufficient to lead to uncertainty of all the [illegible], I am not prepared to say, although from the tenacity of the masonry and from the compactness of [illegible] with which it is put together I doubt very much would it. At the first however when these defects were observed the Dunallan especially was in a very unprotected state, its [illegible] was [illegible] to a great depth [illegible] [illegible] [illegible], [illegible] [illegible] [illegible]. By [illegible] [illegible] [illegible] [illegible] upon [illegible] same rule. [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] that of the [illegible] [illegible] that of the Dunall and [illegible] [illegible] [illegible] that [illegible] [illegible] of the [illegible] had taken place [illegible] [illegible] [illegible]; [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] doubt. The point [illegible] [illegible] [illegible], and the state of the buildings was [illegible] carefully examined by the [illegible].

[illegible] the details. It was during this inquiry that I was taken [illegible] the alterations that [illegible] made in the original design of the blocks for these wings as repre-sented in Diag CXLIX it was sup-posed that had the foundations consisted of an uniform series extending over the whole surface the weight of the superstructure would have had more equable bearing upon the blocks. The blocks numbered 24 26 : 27 as it will be seen from the diagram are com-paratively small and being of the size which practice proved to be the most [illegible]

[illegible] Diag: CL [illegible]

built with two layers. The work done at this time will be understood from the following diagram.



The above [illegible] between the abutment [illegible] a [illegible] a a, [illegible] the [illegible] [illegible] to [illegible] [illegible] the [illegible] [illegible] [illegible] the apron a a [illegible] was [illegible] at the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] that it [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water tight [illegible] [illegible] of the [illegible] [illegible] all [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

by the [illegible] in Fig I, [illegible] laid down
a [illegible] [illegible] most [illegible]
[illegible], at the [illegible]
[illegible]
of [illegible] [illegible] to
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]

As far as the [illegible] and
[illegible] additional [illegible]
[illegible]
[illegible]
[illegible]
[illegible] the opposite [illegible]
[illegible]
[illegible]
[illegible] be guarded against.
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
adding strength [illegible]
[illegible]
[illegible]
[illegible]
[illegible] the following diagram
[illegible]
[illegible]

Fig. CLVII

[illegible] quantity of
broken or rejected brick and
coarse material, which were
collected at the Brick yards
and in the neighborhood of
the works, [illegible]
[illegible] quantity and
compacted [illegible] with great compact-
ness. [illegible] of 3 feet thick
built of rubble masonry was
laid [illegible] with [illegible] along
the whole [illegible] of the
Quadrant, and as much ma-
terial of this description as
could be obtained was added
so as to give weight and solidity
to the whole. Cut stone masonry
[illegible] the [illegible] described,
[illegible] was thrown, the arch
[illegible] with the full weight,
[illegible] the point CC [illegible]
[illegible] part of the Quadrant.
This [illegible] rested on a very
massive abutment A built
of rubble brick [illegible] was
allowed [illegible] before the arch
was constructed. It will be
seen by the [illegible] of
the above diagram that the
whole of this [illegible]
[illegible] by the [illegible]
[illegible] which [illegible] that of the
masonry [illegible] built [illegible]
[illegible] which
was used [illegible] raising the
[illegible] of the [illegible]
above the [illegible] to which it
[illegible] were the [illegible]
[illegible] observed, no other measures
were taken, and it is supposed
that what has been done, will
place

place the building out of the reach of further derangement. The continued and irregular settling of the walls upon which the Quadrants are built, and (what appears to me not at all unlikely) the probability of the sinking of the substructure of that portion of the building upon which the tower itself [illegible]; the [illegible] Quadrant [illegible] although carried up to the top of the wall, and in the closest contact with it, must nevertheless separate; that is to say where the tower and the Quadrant there is no bond in the brick work. By this arrangement a settlement in the Quadrant [illegible] that part of the tower above, and [illegible] to its derangement and that of the tower.

9. I should here again [illegible] the settling of the [illegible] than anything else a slight settlement of the substructure. The [illegible] portion of the building must [illegible] place; the [illegible] was thrown [illegible] coming in contact with those of [illegible] on the [illegible] side, as they had been built up and [illegible] separate that the smallest [illegible] of [illegible] would be [illegible], and the [illegible] of the [illegible] the [illegible] give [illegible] to the [illegible]. – The

[illegible]

walls however, which was then lying on the ground and rested on the steps at the foot of the plinth showed a slight difference of level at the top. [illegible] It was at this structure [illegible] that [illegible] were barely appreciable, although the wall [illegible] feet was [illegible] (plate no 5. [illegible]) [illegible] although there were separate pieces that [illegible] was still [illegible] several [illegible].

It would appear that in displacement of the walls generally that [illegible] the stones being [illegible] taken [illegible] the displacement [illegible] the plan and [illegible] section [illegible] in the Atlas plate XXVII Fig.

Great attention was paid to the [illegible] of the walls upon the plinth [illegible] [illegible] with the [illegible] in stating that such [illegible] however, [illegible] quite [illegible] that [illegible] about [illegible] accepted as proofs of such action where the [illegible] upon which the plinth [illegible] was [illegible] of plain [illegible]. I consider it necessary [illegible] to state the results [illegible] by the Executive Engineer [illegible] whose interest [illegible] was naturally [illegible] the [illegible] having [illegible] the [illegible]

[illegible] dated 11th May 1852, and [illegible]

	Deviations from Perpendicular			
	At 3 feet from up Stream face of Pier	At 3 feet from Centre of Pier up Stream	At 3 feet from Centre of Pier down Stream	At 3 feet from down Stream end of Pier
	Inches	Inches	Inches	Inches
Right abutment	1/4	—	—	—
No 1 Pier	1/2	—	—	1/8
2	3/8	1/8	1/4	1/4
3	—	—	—	—
4	—	—	1/8	1/8
5	1/4	1/8	1/8	1/8
6	—	—	—	—
7	1/8	1/8	—	—
8	1/4	1/16	—	1/8
9	—	1/16	—	1/8
10	1/16	—	—	1/8
11	—	—	—	3/8
12	1/8	—	—	1/8
13	—	—	1/8	—
14	1/4	1/8	3/16	—
Left abutment	—	—	—	1/8

[illegible]

[illegible] required

compared with the [illegible] to [illegible] the [illegible]: this operation was [illegible] during the progress of the [illegible] [illegible], [illegible] [illegible] the [illegible], [illegible] put [illegible] [illegible], [illegible] the upper rock, and was [illegible] dependent on the [illegible] either [illegible] the [illegible] and support of the [illegible] itself, or of the [illegible] and material upon which the [illegible] rested.

The above [illegible] will [illegible] the nature of the difficulties that we had to contend against in [illegible] the [illegible] operations, the [illegible] of the foundation [illegible] at first sight without possibility; that [illegible] the [illegible] a [illegible], [illegible] of [illegible] [illegible] to the [illegible] of themselves.

The [illegible] and [illegible] [illegible] were [illegible] completed by the end of March 1864, and the remaining work which consisted of raising the side and [illegible] walls, completing the [illegible], and making the [illegible] connecting the [illegible] [illegible] with the [illegible] [illegible] was completed without any difficulty. The design of all this part of the work will be understood from the sketches [illegible] to the letters.

The only part of the superstructure that requires special explanation is the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] day.

either for purposes of examination
or repair. — The lower sluice,
[illegible] are [illegible] so [illegible]
a way that they may be ap-
plicable to regulating the
flow of which water [illegible]
by a series of pipes placed
vertically through the
masonry of that part of the
building being in close con-
nection with the head of Chan-
nel. With these pipes a [illegible]
[illegible] from the flanks
of the chambers, with its head
protected by a stone block and
ring of [illegible]. The [illegible]
[illegible] sluice of [illegible] is
situated at that part of the
aqueduct in which the expan-
sion of width takes place; it
is supposed that this will
seldom or ever be called [illegible]
and it has, consequently,
[illegible] a [illegible] application of ap-
paratus for opening and
shutting it, it being [illegible] that the
shutter should be [illegible]
temporary position, at the necessary
pressure of water, by a crab
capstan. This [illegible] which
is 2 feet wide by 3 feet high, is
laid on a sleigh of 4 inches
[illegible] supposing it is necessary
to lay one of the chambers dry,
the planks are applied to the
[illegible] and [illegible]
[illegible] made water tight by
the usual simple expedients.
The [illegible] of [illegible] works
[illegible]
[illegible] the
[illegible] enclosed in the
[illegible]

[illegible], 31st [illegible]
[illegible]

channel and wing buildings into the bed of the Ham River. Each Chamber has two Sluices or Escapes of this kind, one directed towards its upper and one towards its lower wing. The perfect drainage of the Chamber is effected by means of a Cunette, or narrow Channel slightly depressed below the Chamber flooring and with an incline towards the Sluice head. By the means of these Sluices there appears to be perfect facility for laying a Chamber dry, whenever such may be required.

In rear of the pedestals which flank the Aqueduct, and which with their superincumbent Lions stand on each wing, the water measuring apparatus, together with the steps of descent from the top of the Embankment walls, to the bottom of the wing walls, are situated. The latter are covered by a vestibule or block of masonry, corresponding in character with that of the pedestal itself, being on the side of the road of communication which is kept free and open. It is on this road that a single line of railroad is laid, passing above the top of the flanking walls of the Aqueduct, it continues in prolongation along the top of the Embankments. On the left Embankment, this line of railroad will connect the [illegible] of the workshops yard with the works at [illegible].

On the right a similar line will extend from the Roorkee bridge to some point at a convenient point beyond the [illegible] Bridge. The great object of both these lines of Railroad is to establish a rapid means of communication, so as to furnish the utmost facilities for the passage of wagons, in the first place for removal of embankments, and in the second, for the carriage of stores and other purposes. It is [illegible] for the purpose of carrying Earth [illegible] hope [illegible] thousand [illegible] feet that these railroads are devised, and that they should be maintained in perfect order for these especial purposes, it is a point of some importance, as regards the security of the Aqueduct works, that no time or labor should be spared in securing their efficiency.

Next therefore the Question of establishment for the main drainage of these stupendous Embankments arises; and in considering the details it must be recollected that the whole of the Earth carriage must be brought from the sides of the valley towards the centre, in fact from the particular circumstances in which the Roorkee buildings are situated with regard to the Aqueduct it appears to me, that Earth can only be procured from Excavation...

I consider it to be a

law

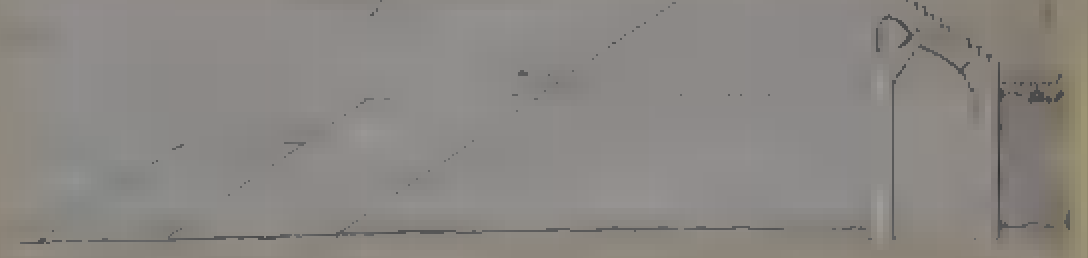
law that no excavations are to be made on the surface of the valley at the foot and outside of the Embankments. My views at present are strongly opposed to any measures leading to outside excavations; those which have been already done cannot be undone; they were commenced at the early part of our operations, and by smoothing off and sloping the ground to their margin [illegible] they are at present no more [illegible] eyesore. There can be no doubt, however, that in removing the surface soil of this particular point, and by so doing increasing the difference between the water level in the tanks and the surface of the valley, no benefit can be derived ultimately. We have, moreover, established low patches of ground, the perfect drainage of which is indispensable to the salubrity of the country as well as to the appearance of the tanks. The most efficient means of drainage are offered by nature in the slopes which she has given to the country, but it will require active measures to keep the ground in order, and [from] keeping it free from the rank vegetation which invariably accompanies land of this sort in the Tropics.

The state of the exterior Embankments as explained in the foregoing paragraph appears at once to

point

pointing out the advisability, if not the necessity hereafter, of protecting the external slopes especially those in the neighbourhood of the Tunnel, where the embankments are very high, by a berm or series of berms as is represented in the following diagram, raising the surface of that next to the original embankment to the height of the bed of the channel, or even higher if such would be considered advantageous; by such an arrangement the embankments would be so strengthened as to remove all danger, and the contingency of leakage would be diminished [illegible] the Tunnel.

Fig CLVIII



This work might be effected by the Establishment maintained for the repairs, and might be considered the stock work to be carried on at all times when the men and wagons could not be employed elsewhere. A better employment could not well be given to them. The prolongation of the steps on the exterior slopes, to meet the extent of berm above them would be a very simple process. In the above diagram where there are 3 tiers of slopes

-ade

-ades, the steps would merely be prolonged to meet them.

The amount of Establishment proposed to be kept up for the repairs and maintenance of the Aqueduct has been determined on the number of Earth Wagons which it might be necessary to keep constantly at work; in cases of emergency daily labourers could be called into requisition, and for these occasions spare wagons would be kept in store.

I propose that similar parties under the same system of discipline as those which are provided for the works lying above the Aqueduct should be maintained for Aqueduct purposes. There should be two of these parties consisting of 4 Mates and 40 Beldars each divided into gangs of 1 Mate with 10 Beldars under him. These parties should have their separate charges clearly defined, one being attached to the right and the other to the left bank.

To each party 15 wagons should be attached, all kept in perfect working order by periodical inspections both of wheels and frame work. Of the above number of wagons twelve would be in constant use, that is to say, allotting 3 men to each wagon with 4 spare men for other purposes: and keeping 3 wagons in store to replace those that might be disabled during the day's work.—

Besides

Continuing

Besides these 15 wagons, which should be considered as employed on the works, I would recommend that there be 15 others allotted to each party but remaining in store, so that in emergency and when additional parties of daily labourers were necessary for heavy repairs, a total force of 30 wagons might be available for each establishment.

The parties might with advantage be stationed at both [illegible] and [illegible], in equal divisions; it might be convenient also to keep the wagons at the latter place from whence the main supplies of earth will be drawn. The buildings, [illegible], which now exist at [illegible], may be usefully turned to account in giving [illegible] to this permanent establishment.

In the early period of progress I would also make a selection of 26 of the best horses that remain in the stables after the heavy works are completed, for pulling the wagons and aiding the labour parties, as it will be at this period in all probability when, from the settlement of the Embankments, more work will be required than it will be afterwards. It is, in short, very desirable that from the period when water is first admitted every care and attention should be given to the consolidation of

of

of the Embankments, and this can only be effected by prompt measures for the delivery of earth at those points where settlement is observed.—

The Establishment therefore that I propose for the Aqueduct is as follows:—

	Mates	Beldars	Carts	
			In use	In Store
Right Bank	4	40	15	15
Left Bank	4	40	15	15
Total	8	80	30	30

with 20 Horses for the use of the carts, thus giving 15 for 30 carts with 5 spare ones.

Time will shew us how far this amount of Establishment may be considered sufficient for the purposes required from it, and whether it may be necessary to retain the Stable Department, which is a troublesome and an expensive one. In the meantime, however, I am satisfied that it would be unwise to trust the Aqueduct works to smaller parties. Much requires to be done independently of mere consolidation; the completion of the slope turfing, the drainage and proper adjustment of the ground on the outside of the Aqueduct, prompt remedial measures for cutting and disarrangement of earth during rains, are points which if looked after in the few first years of progress, will in all probability give

little

little trouble afterwards

On the aqueduct itself I have only a few words to say further, viz: that the preservation of the Earth embankments from Trees and jungle, and, if possible, the riddance of all vegetation excepting Doob grass which ought to cover the whole of the slopes and at least 3 feet in width of the upper flat in connection with them, appears to me to be very desirable not only for the purpose of preservation, but for the general appearance of the work.

The existing Aqueduct will be changed at some future period, when the effects of the water passing over it have been well shown, and when other more important arrangements do not interfere with its progress.

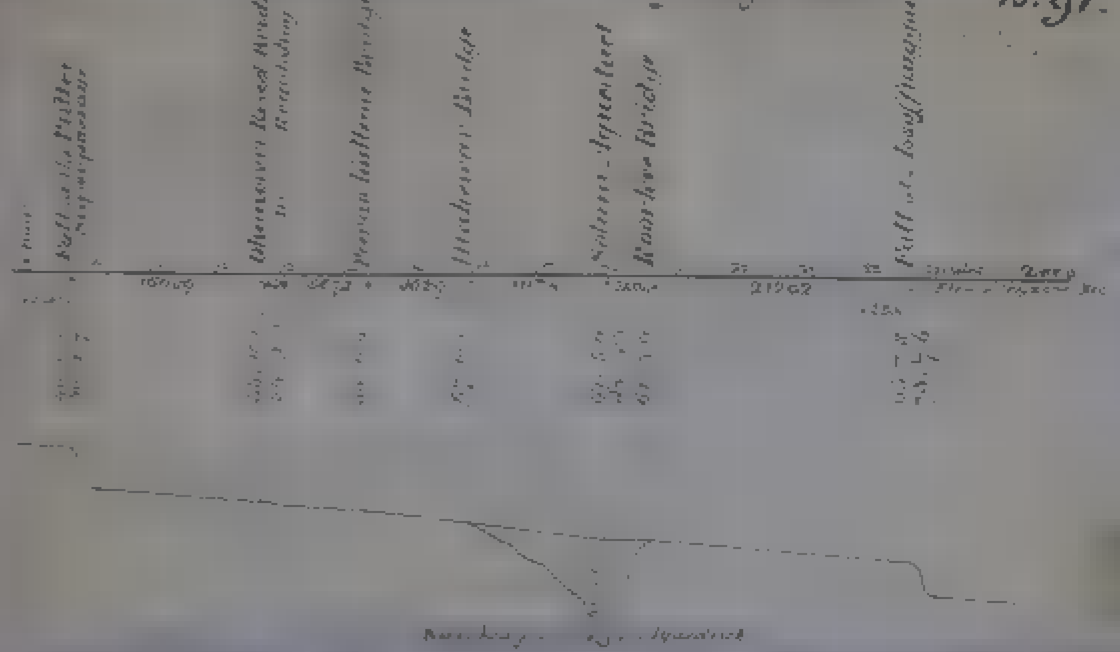
The levels of the Canal bed as connected with the Aqueduct are the most important part of the whole design. These and the works connected with them, have been most anxiously considered, and from first to last have been the centre to which all my thoughts have radiated.

The following section of the Canal bed from the tail of the Puthri Falls and supply passage to the Head of the Assofnuggur Falls, is the best introduction to this subject.

Diag.

Diag: CLIX

B.91.



It may explain that on the whole line of Aqueduct the tops of the Embankments are laid down on a slope of 1.5 feet per mile, and the masonry revetments and other works appertaining thereunto are adjusted to this particular slope. The Canal bed, however, is on a slope of 1.25 feet per mile, so that above the upstream end of the Aqueduct or at a distance of 3 miles from the Roorkee bridge the Esplanade is 7 inches higher than it is at Roorkee.

Referring to the section now given it will be observed 1st that the slope of the Canal bed from the tail Chamber of the Puttree falls to the flooring of the Roorkee bridge is equal to 1.25* feet per mile; 2ndly that the slope of the Canal bed from the flooring of the Roorkee bridge to the sill or wasteboard of the Assufnuggur falls is equal to 1.096 per mile; and 3rdly that the flooring of the Aqueduct is laid on a level† with that of the Roorkee bridge.

It will be understood from the data above given that the effective slope of the

Note * Actually 1.2375 by [illegible]
† [illegible] 2 inches [illegible]

the whole line, viz; from the tail of the Puttri falls to the head of those at Assofnuggur is (65.78) − (50.17) = 15.61 ft in 68600 feet or 1.193 per mile.

The tail curtain walls of the Roorkee Bridge is laid to a depth of 20 feet so as, as far as possible, to preclude all chance of evil from the action of retrogression. This Bridge moreover, has been made the point on which a change from a high to a low level has been effected, and consequently, has become in a greater or less degree removed from the effects of the above evil; it will be subjected in all probability to deposits. The tendency of the low levels from Roorkee to Assofnuggur is to throw back water upon the Aqueduct channel, to modify the declivity of bed, and to give the latter a certain amount of alteration.

The Aqueduct flooring which is situated at a distance of 800 feet from that of the Roorkee Bridge, is I have been placed on a level with it. The object of so doing in this case was similar to that before described, where the raising of the sill of the Assofnuggur Falls has a tendency to throw a deposit on the flooring of the Roorkee Bridge which lies on its upstream side. Here the position of the Aqueduct flooring

flooring renders it liable to deposits from that of the Roorkee bridge, so that what with the floorings of both the falls and the Bridge, the Aqueduct is not only protected to a certain extent from retrogression of levels, but there is a tendency to the formation of deposits over its whole surface. -

It will be understood that the true slope of the Canal bed from the Mukiwan to the Roorkee bridge, intermediately with which the Aqueduct is situated is 1.25* feet per mile. The flooring of the Aqueduct therefore which is situated [illegible] feet above the Bridge ought to have been raised 8† above it instead of being on one level had uniformity of slope on the whole line been determined on; there was a great object, however, in depressing the flooring of the Aqueduct, so as to remove the action of water in ingress and egress as far as possible from the masonry, in fact to deprive the water, if such could be done, of all action, and to secure a steady and easy flow over the works. -

How far the arrangements that I have devised will answer remains to be seen; whether there is any advantage in keeping the Aqueduct flooring depressed remains to be proved. The [illegible] object of the first has been

feet
* [illegible] 1.25 [illegible]
† [illegible] 7.46 [illegible]

been to protect the line of raised embankment from the effects of current, and to reduce as far as possible the action of the water in passing from masonry to earthwork; that of the second, is closely connected with the same object, but its results should shew the necessity for raising the flooring of the Aqueduct to the height demanded by the effective slope, the remedy is an easy one, and the addition of the required layer of masonry may be combined with measures for securing watertightness by the intermixture of either Asphalte or other bituminous ingredients.

The following Tables will show the amount of water discharged through the Earthen Aqueduct Channel, as well as that which the masonry channels of the Aqueduct proper are capable of carrying at different heights or depths as noted in the 1st Column. — The velocity being estimated at that due to the effective slope of the canal channel from the flooring of the Puttri Falls to the sills of those at Assofnuggur, this being.

Table I. Earthen or revetted Aqueduct

D	R	Velocity V	Velocity v	Velocity U	Area	Discharge per Second
1	11·83	1·50	2·57	0·19	150	192
2	23·40	1·95	2·17	0·47	300	546
3	34·59	2·52	3·76	0·68	450	1,99
4	45·57	2·55	4·20	0·90	600	1530
5	50·46	2·82	4·58	1·06	750	2116·13
6	60·07	3·06	4·88	1·24	903·7	2765·83
7	74·33	3·27	5·15	1·34	1060	3466·50
8	82·86	3·45	5·43	1·57	1216·5	4207·375
9	91·12	3·62	5·62	1·62	1382	5002·84
10	99·67	3·74	5·86	1·72	1548	5866·03
11	106·75	3·93	6·05	1·81	1716·5	6345·825
12	114·[illegible]	[illegible]·08	6·20	1·96	1888·5	7705·65

Table II. Aqueduct Profile Masonry Channel

		Velocity				Discharge per second	
D	R	V	u	U	Area	One Chamber	Both Chambers
1	11·735	1·28	2·37	·19	82·080	105·0624	210·1248
2	23·102	1·81	3·17	·45	166·248	300·9088	601·8176
3	34·081	2·20	3·72	·68	251·137	552·5014	1105·0028
4	44·808	2·53	4·20	·86	336·137	850·4266	1700·8532
5	54·678	2·80	4·54	1·06	421·137	1179·1836	2358·3672
6	64·333	3·04	4·88	1·24	506·137	1538·6565	3077·3130
7	73·367	3·25	5·24	1·30	591·137	1921·1453	3842·2906
8	81·622	3·43	5·38	1·48	676·137	2319·1444	4638·2888
9	90·447	3·61	5·62	1·60	760·704	2746·1344	5492·2688
10	98·643	3·77	5·86	1·68	844·616	3184·2023	6368·4046
11	104·430	3·88	5·95	1·81	927·463	3598·5564	7197·1128
12	111·661	4·02	6·15	1·84	1009·463	4058·0413	8116·0826

Dawson

We come now to the bed of the Solani River itself, and the works that have been designed and executed, 1st for the direction of its course upon the waterway, and 2ndly for retaining the current upon this course afterwards, which brings us to

Section III. Bunds and Embankments on the Solani River, in connection with the Aqueduct.

From what has been said before, it will be understood that the foundations of the aqueduct building, in addition to the river [illegible] blocks [illegible] was substituted for that of [illegible] as originally planned, have both in front and rear of the floorings, curtains and aprons consisting of frame boxes filled with heavy material and covered with lines of planking. Referring to the plan in the Atlas it will be seen that the flanks both on the upstream [illegible]

down stream in immediate con-
nection with the Aqueduct
have been protected by similar
work, somewhat different in
disposition, but all tending to
protect the ~~building~~ from any
injurious action from the current, when passing
through the waterways. The
Aqueduct building itself
though, as well as its imme-
diate neighbourhood, is as [illegible]
[illegible] as
as to be protected by [illegible]
[illegible]
to be [illegible] very efficient.
[illegible] the [illegible] of
the [illegible] with
which the [illegible]
[illegible] in the upper part of
the [illegible], it will [illegible]
[illegible] that the bed of the
[illegible] constant
change of direction, [illegible]
cutting [illegible] one side the bed
that is [illegible] on
the other, and that here also as else-
where, nature appears to [illegible]
[illegible]
[illegible] valley [illegible]
by the [illegible] the
[illegible] of the [illegible] are
[illegible]

[illegible]
"[illegible] It will be observed
that the [illegible] of the Aque-
duct across the valley from
[illegible] to Roorkee lies
at an acute angle with that
of the bed of the river, so that
its course [illegible]
[illegible] with the [illegible]
of the work. The [illegible], which
[illegible]

ed to the inconvenience as well
as accident that I have before
described as having happened
to the Left wing during the
floods of 1850 at a period
before the Revetments and walls
were completed, could not have
been remedied until the water
ways on the Right were suf-
ficiently advanced, to admit
of changing the course of
the River; and it was not
until the cold weather of 1850/51
or that immediately succeeding
the rains when the above inter-
ruption took place, that we
were able to commence the
works on the Valley.

A reference to the plan
above referred to will explain
the steps that were taken for
the purpose, better perhaps than
any description that I can give
herewith. Our object was to
bring the course of the Torrent
fairly and directly upon the
waterways, to get rid of the curved
bed, the inclination of which
was towards our embankment,
and obliquely upon the face
of the Aqueduct. A series of
levels having been taken so as
to show the contour of the land
in immediate connection with
that to be operated upon & I
carried a line in prolongation
of the longitudinal axis of
the Right bay upstream un-
til it met a curve of the river
as shown on the map, the dis-
tance between the Aqueduct
and the meeting of the curve
by

by the line in prolongation being 2,400 feet. On this alignment the new course of the River was to be directed and for attaining this object [illegible] a series of numerous small channels as at a.b.c. d.e.f.g. to one or two lines, so as by multiplying the channels the surface of soil to be acted upon by the current was greatly increased, and it was by the action of the current that it [illegible] proposed to [illegible] a channel sufficiently large for the passage of the water. The trial dam was constructed in [illegible] two parallel lines of 50 feet width each in prolongation of the [illegible] their position being shown in the plate.

The slope of the bed of the channels were to be uniform commencing from the upper bed at B and terminating on the Aqueduct. The slope was in fact 1.76 feet per 1000 feet from a point on the [illegible] to the Aqueduct [illegible] above the former

The excavated earth from the Channels a.b.c.d. was thrown on the right, that from the Channel e on the left —

The Channel [illegible] a. for the passage of the [illegible] into the Channel e, was made 5 feet in width with a [illegible] of 7 feet in width the earth excavated from the [illegible] thrown on the right, that from g on the left bank

The

The Bunds which are described in this plan at right angles to the cuts and to the current that was to pass down them were made from sand or soil thrown up from the pond & lacon.

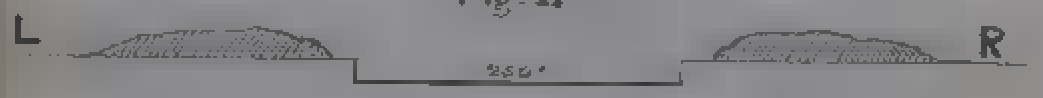
The levels were determined by points which were fixed on the Contour these together with the orders which were given on handing over the work to the Executive Engineer will be seen on the face of the plan.

The transverse section of these 5 cuts compared with that of a single Channel with its waterway, will shew the advantage that the former has over the latter where mean area [illegible] is the object to be gained; it is a very good illustration of the value also of that element in the formula for discharges through pipes and Channels, consisting of the accurate measurement of the wall, or of the Perimeter in contact with the fluid.

Diag CLX

Fig: I

Fig: II



Here in comparing the value of the wall or surface to be acted upon in the figures above given (supposing for simplicity sake that the depths are 10 feet) we have in the first case 70 × 5 = 350, and in the second 250 only. The discharge in the

1st Case supposing that the walls of the Channel were rigid proportionately less than that in the 2nd — The action of the flood, however, on the smaller Channels (which would in the above case reduce the amount of discharge) [illegible] tends to enlarge and widen the Channel, and [illegible] to gain the effect which is desired.

Economy again enters into the plan which has been adopted, not only in reducing the extent of Excavated Channel, but in rendering that Excavation more easy, by shortening the distance to which the Earth has to be removed.

The action of the Floods during the rains of 1857 which was the first rainy season in which the Floods were passed down the Cuts and between the Abutments of the Aqueduct, was comparatively slight. The Cuts, however, did thoroughly [illegible], and the banks entirely turned the river from its old course. During this rainy season, the piers and springings of the Aqueduct and the piers placed intermediately for the support of the railway were in progress.

The first flood was a very early one, and came rather unexpectedly at 6 P.M. on the evening of the 11th June; the 20th of that month being usually considered the time up to which the works were tolerably safe from floods. The

time

The Cuts were, however, completed with the exception of small bars across 2 of them left until the last moment for the purpose of cross communication. The current came down through the Cuts leaving the old bed of the river high and dry, and not interfering with the bunds in any way. The water of this flood rose 4 feet above the flooring.

On the 9th of July a flood 2.75 feet in depth on the flooring passed off without doing any damage, although showing an inclination to cut in the right upon which the current had made a set. The Executive Engineer, however, stopped up the heads of the 2 Cuts A and B, as well as the 2 right water ways of the Aqueduct. During the flood it was supposed that at least 4/5ths of the volume passed down the above 2 Cuts & bunds which were made were raised merely above the surface of the ground, so that they might be topped by water rising above 6 feet. It must be understood that at this period the flank protections to the abutments on the River side had not been built, and that it was of the utmost importance that these parts of the work should be removed from all danger.

The upstream friction of the main Aqueduct and for the support of the Railway

the

on the upstream face were at this time completed. On the 11th of July, and in reporting the above flood it was stated "that our cross communication "with the two banks is now "complete for foot passengers, "and the railway will in a "few days be laid from Abutment "to Abutment. The work re-"maining, however, to complete "the piers on the down stream

Wilkin

"side [of the Aqueduct ready "for training is very consider-"able".

The state of the 5 Cuts after the above two floods was not much changed, the edges of the two right ones had become eroded or broken into ravines; in some places the earth had fallen in, 11 feet from the original digging, but the average was not more than 4 or 5 feet, and at many points the banks were hardly cut away at all.

On the 11th July a flood 4 feet high, about the Aqueduct flooring passed down the river." The 2 right Cuts having been bunded up at their heads, all the water came down the 3 others c, d, e. Although, moreover, the 2 right waterways of the Aqueduct were bunded, not the slightest action was observable on the right abutment. This flood was not sufficiently high to test the measures that had been taken, but the results as far

far as they showed themselves were duties acting.

During this flood, work was carried on as usual on the superstructure, although water was flowing through the 11 Centre Arches.

The effect of turning the River from its old course appeared at this time to influence the movement of the Current above the head of the Cuts at the point B. The stream began to abandon the turn or deep loop on the right bank above the Cuts until to come perpendicularly down on the alignment of the Centre Channel. We found it, therefore, desirable to ease off the sides of the Cuts in places where the natural soil would not give way, as this supposed acted as a cross project check to abrasion, which instantly took place on its removal.

On the 29th of July, a 4ft flood passed down without causing any inconvenience, and was as easily disposed of, as the former ones. The effect of this flood placed at rest any doubts about the efficiency of our Cuts and bunds. The water passed down 3ft the dyke at the head, and broke through the bund at the head of Cut 6, not owing to its having topped the bund, but to the action of the current on its face.

Up to the termination of the rainy season of 1851, very little rain had fallen about

Roorkee

[illegible] in itself, the Plan of works originated entirely from the altered condition of the Locality. The results of our works is however, were very satisfactory especially the Intake of the main Canal with its bunds, &c and, in connection with which I had Burroughs anticipated much trouble.

Previously to the setting in of the rains of 1853 the series of Arches marked in Diagram CLIII as 1. 2. and 3. had been completed, and the 4th was in progress during the months of June and July. On the 9th of August [illegible] on the day of [illegible] of the [illegible] way, the whole of the down stream half of the Aqueduct was [illegible] at this time, therefore, began a new period in which the floods had to act on the work with the down stream half loaded with Arches, and the upstream piers and railroad supports acting as obstructions to the current.

As in the season of 1852 the floods were earlier than usual, a small one came down the River on the 15th of June without doing damage of any great importance, although it reached the works when the bunds were under repair. On (M.M. 524 v.2 p.iii.) the 5th of June, a flood [illegible] in the evening, and on the [illegible] of July, one of [illegible] passed under the Aqueduct. These

were

were heavier floods than we have experienced, but they passed off without doing any damage although at the time they were running, the 2 bays on the right, as well as the 4 on the left, connected with the Aqueduct building of the 4th series were entirely closed. I am desirous of entering into the fullest detail on these matters, as the position of the works during this, as I may call it, initiatory period is of much importance and intimately connected with the value of the waterway of the Aqueduct. For instance, in the flood of the 19th July, there were 6 out of the 16 bays closed, besides the obstruction given to the free passage of the water through the remaining 10, by the interposition of some bays of 4 piers for the support of the railroad.

The effects upon the bunds arising from the above floods were as follows: the main or leading bund D, situated at the head of the Cuts, and which crossing the old bed extended some way into the country, was broken at its intersection with a hollow at a point considerably to the left of the River; as far as practice went this was the only bund that suffered.

The retrogression of levels which was necessarily attendant on the new Cuts had acted

considerable

considerably. The beds of the Cuts which were level with the natural soil at the point guarded by the "nulla bund" were at this time 3 feet below their embankments; and perpendicular falls or drops had established themselves downwards. The same was in operation on the 2 Cuts f g. connected with the Tooke nulla; the Eastern one g being about 2 feet deeper than it was originally excavated, the Western Cut f was little affected by the floods.

On the 20th of August there was much rain and the Solani rose to a height equal to that of the 1st of July, or 3 feet off the Aqueduct flooring. These heavy floods did great good in clearing away the remaining sand that existed in the neighbourhood of the works, from the block sinking and foundation excavation. After the flood of the 20th August, the main set of the current was straight through the Centre water way, and from thence straight against the Old bank opposite the village of Muhiuddinpoor: the deep water running close under the bank on the opposite side to where my Estate is situated. —

The rains of 1852, therefore, passed away, not only without doing damage of any description, but in giving me increased confidence in the works on the Solani valley,

as

as well as in the sufficiency of the waterway of the Aqueduct, and of the protective works connected with both its flanks and its foundations.—

During 1853. the rains were by no means continuous throughout the season; in the early months there was a good deal with much interruption to work but latterly hardly any rain fell at all; there were, however, some heavy floods which occurred at a period when the Aqueduct from having — of its bays closed, stood a still further test of its sufficiency in all purposes required. The last Arch was keyed on the 1st July 1853. previously to which a flood ~~[illegible]~~ came down on the 10th [illegible] and stood 3¼ feet on the Aqueduct flooring, during which the following bays (vide Diagram CLIII) Nos 4. 8 and 12 were shut. Now, this was more trying than on any other occasion, from the circumstance of the centre bays of the Aqueduct being interrupted; no injury however arose either to the bunds or to the masonry work, and the cuts became very much enlarged. The result of this years rains was in fact more satisfactory than that of the years which had preceded it, and added, if any thing was required to do so, to the confidence which I had already expressed of the stability of the Solani works

I have not attempted to describe in all their details the different additions that were made to the bunds &c during the 3 years since the Current was placed in its new channel. Some of the bunds originally proposed were omitted, others have been extended both in length and increased in proportions. Low ground on the right and in the vicinity of the Aqueduct itself has been protected, and much improved by detached works which circumstances showed to be necessary; and the greatest attention has been given to the permanent security of the whole.

Plate XXVII of the Atlas will show this detail, and explain the changes that have been made during the continuance of our operations, as well as the effects upon the Cuts by the action of the Current during the rains of 1852 and 1833.

The true slope of the bed of the Solani River as affecting upon the Aqueduct flooring was determined very carefully by me in 1844, by a series of levels taken on a length of 10 miles - 8 of which were above and 2 below the site upon which the work has been built. On the above length the total fall was 50·84 feet or 5·08 per Mile.—

It will be understood that by the change of course and

and by the straight direction upon which the new cut has been brought to bear upon the Aqueduct, the natural regimen has been disarranged, and that as I have shewn elsewhere the straight cut which brings the water upon the upstream face has a slope of 6.37 feet per mile, an excess of slope which is uniform on the whole length of the cut over a distance of 9070 feet. The rapidity of the slope thus given to the bed on its approach to the works has a favourable tendency towards the establishment of deposits on the flooring of the Aqueduct, and to protecting the bed from the erosion which an uniformity of declination of bed would have led to. The effect I imagine here, will be similar to that which I have before explained, as having arisen in all cases where by a change of slope in a Canal bed, a rapid descent delivering the water upon a line of a reduced fall, the slope of which is insufficient to carry the water onward at the same velocity with which it arrives at the point where the change of level took place. For instance in the bed of the Jumna to which our attention is now directed, we have the bed in connection with the flooring of the Aqueduct similar to that shewn in the following diagram.

Diag. CXI.

a e b and c d are parallel to each other and of a slope of 5.08 per mile, the intermediate portion b f c being on an increased declination of 6.37.

There can be no mistake whatever on the results of this arrangement, they have in fact been from the period when the water was first poured down the cuts in constant progress towards completion; rapids and abrupt descents have been establishing themselves in the bed of the cuts, with a retrogression of levels, the abraded matter being thrown in advance in other words the [illegible] in the above section e b f is undergoing abrasion and removal, whilst the soil so removed is thrown on the floor of the aqueduct. The results of the action which I imagine to be taking place ~~the~~ are clearly exhibited above where the dotted line points out the surface of the true bed of the river as it will ultimately appear, when the water has fixed for itself a regimen dependent on the slopes which we have given to the bed.

Passing aside therefore the fact of the great advantage given to the work by bringing the torrent to bear directly upon the bays, by which the protective measures for the flanks, and the discharge of the bays themselves have their fullest weight, the foundations of the Aqueduct itself

itself durable the greatest of all possible protections from the results, which I have above described, of deposits.—

The slope of the River although comparatively small when placed alongside of that of other torrents with which we have had to deal, is still considerable. I am of opinion however, that from the great extent of waterway which has been given to the passage through the Aqueduct, and consequently to the diminution of obstruction to the deposits on the flooring reducing the action of the current in its passage during floods possibly to a point beyond [illegible] the masonry flooring & foundations; and to the superficial character of the River on the down stream side, with the formation of a somewhat rocky [illegible] of the Rutmoo stream about 2 miles below it, that a retrogression of levels upon the Aqueduct [illegible] is not to be anticipated. My best endeavours, however, have been to provide against a contingency of this sort by a consecutive line of piles driven close together at a distance of 20 feet from the masonry flooring, the intermediate space being filled with boxwork and heavy material confined in its position by sleepers; an arrangement that will be understood by an inspection of

the

[illegible] the plans.—

Viewing as I do the occurrences above alluded to as improbable, I have had no hesitation in carrying out the cuttings in prolongation of the abutments on the down stream side of the bays, so that the current may run fairly off, and not be interrupted by the turn which the old course of the River gave it immediately on its escape from the waterways. A great object that I have in doing this, is to keep the water at a distance from the Pro[illegible] of the valley, and to form the border resting on the right of the line a' a' a', into a raised platform smoothed off and turfed, [illegible] exists on the right of the old River. A work of this sort can be easily done by teaching, and making the ground deposit silt on the bank that requires to be raised. The improvement, but is an inexpensive one to the station and can be done gradually by the aid of the Establishment which must be maintained for the purposes of the Aqueduct.—

In estimating the theoretical, as I have already given the efficient practical value of the waterway of the Aqueduct in passing off the floods of the Plains, I shall treat the subject in the same way that I have done the Inlet passages, i.e. by estimating

the area of the Catchment basin which depends upon the Aqueduct for its relief from drainage, under assumed falls of rain over that Catchment basin —

Supposing therefore, that 12 inches of rain fall over the whole surface, viz 216 Square miles in 24 hours the total quantity of water that had fallen would be.

5280^2 = 27,878,400 cubic feet in 24 hours
1,161,600 " in 1 hour
322.666 " in 1 Second

therefore the discharge per second would be thus:

322.666 × 216 = 69695.856 cubic feet

It is unnecessary for me to enter into the variety of causes that would interrupt the regularity of the above discharge, nor the probabilities of heavier falls than 12 inches in the time given, for this reason, that although the rain gauges do exhibit occasionally a greater amount of fall, as high as 3 inches in one hour, such falls are limited to small areas, and arise in nine cases out of ten from the breaking up of a detached mass of cloud hanging over a limited tract — As far as my experience has gone I believe that an estimating at the rate above given, and over an area as above described, is in excess of any actual fall of rain that has ever been recorded; and that an average fall per square mile of 322.666 cubic feet per second as ~~falling~~ occurring upon an area

area of 240 Square miles, is a fair and liberal allowance to provide against.

The following Table explains how the above discharge will be met by the waterways of the Solani Aqueduct. The 1st Column shewing the depth of water and the last, the actual discharge through the 15 bays of the Aqueduct due to that particular depth.

D	R	Velocity V	v	U	Area	Discharge per second 1 opening	15 openings
1	11·424	2·808	4·237	1·079	40	112·320	1684·800
2	20·217	3·313	5·366	1·770	85	324·105	4861·575
3	28·950	4·503	6·760	2·246	135	607·905	9118·575
4	35·262	5·202	7·673	2·731	185	962·370	14435·550
5	47·000	5·775	8·294	3·256	235	1357·125	20356·875
6	55·161	6·264	8·940	3·598	285	1786·665	26799·975
7	62·813	6·688	9·486	3·890	335	2240·480	33607·200
8	70·000	7·067	9·985	4·148	385	2720·795	40811·925
9	76·764	7·404	10·304	4·604	435	3220·740	48311·100
10	83·143	7·709	10·093	4·725	485	3738·865	56082·975
11	89·167	7·986	11·069	4·983	535	4272·510	64087·650
12	94·[illegible]	8·257	11·367	5·157	585	4830·345	72455·175
12·542	97·824	8·365	11·405	5·295	612·083	5120·074	76801·110

I have retained the slope at 5·06 per mile that being the natural one of the Aqueduct; the modifications which have arisen from the alterations about the Aqueduct, would if anything rather tend to increase the velocity than otherwise and consequently to increase the discharge.

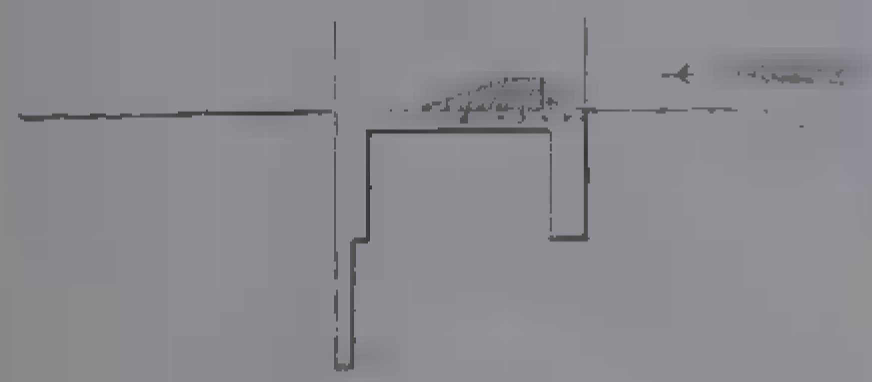
It will be seen from the table that high water on the piers equal to 11½ feet in depth would give a discharge very nearly equal to that which I have estimated as a maximum whereas the full value of the waterway which I consider to be up to the spring of the Arch or 12·542 feet above the level of

the

the flooring would admit of a free discharge equal in amount to 76801·110 Cubic feet per second.

In concluding this Chapter I may add, that previously to turning the water over the Aqueduct, a temporary weir or overfall of 30 Inches in height was raised on the flooring of the Roorkee bridge; this was built in each of the bays of brickwork, its section being as follows.

Diag: CLXII



The object was to retain back water upon the Aqueduct, to save the bed from wear during the early period of its being used, and to give efficient aid to consolidation. Subordinate to these it gave additional depth of water for boats, during the period when the boulder stratum was in progress of being laid down.

The bar of masonry can be removed in half an hour or even in less time than that, should it be found to be unnecessary, or conducive to injury. It will be removed entirely when the Aqueduct bed is perfectly adjusted.

With reference to the lower bays of the Aqueduct through which the torrent passes

passes, it would be desirable to see by experience whether Overfalls or bars like those above mentioned might not be built on the flank bays, or in those next to the Abutments. These might be built to the height of heavy floods, say half the height of the piers or $\frac{12.457}{2} = 6.228$ feet above the flooring. The advantage of these arrangements would be that they would protect the flanks, by keeping the current at a distance from the Abutments in all common floods; in all in fact that did not exceed 6.228 feet in height. The effect would be to throw a long sheet of [illegible] of 60 feet in width on backwater, which would by no means injure the appearance. It is evident however that if the water[illegible] can bear it, the proposed [illegible]-falls in the flank waterways will give a very efficient cover and protection to the abutments.

CHAPTER X.

Excavation of the Canal Channel.

The general design upon which a Canal for irrigation is projected has been sufficiently explained in previous chapters. In this place I propose to confine myself to the method adopted, with reference to the [illegible] of the channel, and to the practical operations for its construction. It will be understood from what has gone before [illegible] that the main object of a Canal is [illegible] the [illegible] for the distribution of water over [illegible] the adjoining ground to be watered, and to place them in such a [illegible] position with reference to the areas to be irrigated that there may be as little difficulty as possible in effecting this distribution. For the purposes [illegible] the [illegible] arrangement of the [illegible] country [illegible] ~~[illegible]~~ regulating the quantity of water which passes through the Canal channel, the [illegible] must be [illegible] facilities for escape & consequently ~~[illegible]~~ [illegible] local [illegible] which it is [illegible] connected with the boundaries it is necessary to provide for the escape of [illegible] & the heavy floods to which the [illegible] are subjected; therefore it is equally [illegible]

desirable to obtain the aid of the natural lines of drainage in receiving waste water which it may be necessary to throw off from the Canal Channel. In both these cases, much care is requisite, as upon them depends the efficiency of the works as a machine for irrigation and the health of the neighbouring population from want of perfect drainage. It will have been seen that the Ganges Canal in its passage through the lowlands at the foot of the Siwaliks, is connected with extraordinary difficulties in the leading 19 miles of its course. On its arrival on the high land of the Doab at Roorkee, the channel thereafter lies between two rivers, the beds of which are more or less depressed below the lands upon which the Canal Channel is carried; its line, as far as straight lines can be run upon intervening [illegible], upon the central ridge from whence the water flows away to the natural lines of drainage, and consequently although the flood water on the high land may occasionally be interfered with by the raised banks of [illegible] which the Canal is laid out, the proximity of these [illegible] to a lower level offers every facility for the object being overcome by artificial means. It is obvious that this same cause is favourable in regulating the Canal by the formation of Escape channels into the beds of these rivers, and that command is obtained over the [illegible] in the tracts under [illegible] most especially available for irrigation.

In Table F of the Appendix

I have placed the original explanation of the method adopted for fixing the size of the Excavated Channel. This method has not been departed from in the Project of 1856, although in details it has been much modified; the causes of these alterations have been before explained. In the [illegible] or headworks they depended on a change in the works connected with the Mountain Torrents, and are, therefore, chiefly due to the Engineering; in the lower or outfall tracts they depended mainly on Revenue and measures for distributing the water with the greatest advantage to the Agricultural community as well as to the interest of the State.

By reference to the Table above alluded to, it will be observed that the design of the capacity of the Channel is founded on calculations based on the volume at a given point, the precise volume of water passing the Canal at that point being known. This being the case, the only questions that remained to be determined, are 1st the slope of the Canal bed, and 2nd the depth to which the water may be carried. Both of these points are [illegible] in determining the capacity, but the 1st is regulated in a great degree by the necessity that exists under the climate of these provinces for preventing the growth of water weeds, and the 2nd by the desire for maintaining the depth of water, and of avoiding as far as possible with the due and depth of excavation, what is called ba

Cummins

=nically in the experiment in "within soil".

The slopes of the bed there-fore require to be dependent on the freedom of the water from vegetation, and at the same time the action of the current upon the soil. In the Ganges Canal works they have been limited to 2 feet per mile in the shingle tracts at the Canal head, and to 1 foot per mile in the channel below them. From the Ranipoor Superpassage which is at a distance of 6 miles from the head at Myapoor, the slope of the Canal bed in fact varies from 1·25 to 1 foot per mile, these slopes are carried as uniformly as possible in long lines, and they are sustained at every bridge by the floorings, which act as retainers for restricting the effects of retrogression. For this purpose the floorings and flanks of the bridges are well protected. It will be seen from what has gone before, that fall of country in excess of the above slopes, has been disposed of by abrupt masonry falls, over which the water passes, and that at the Solani Aqueduct and its neighborhood, certain modifications of slope have been made, depending on the protective measures which have been thought necessary for that work.

The depth of the water, or that to which high water mark is limited, was a point very prominently insisted on by the Medical Committee in the report to which I have drawn attention in an early part of this paper. It is one, moreover, of which I entirely approve, and to which in fact an[illegible]

[illegible]

[illegible] no particular need
[illegible] particular [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] are avoided, this is a
fact [illegible] attaches [illegible]
[illegible] not only in [illegible]
[illegible] and its probabilities
of accident. On the other hand,
[illegible]
[illegible] attended
[illegible]; the
[illegible] may
be considered [illegible] not [illegible] pre-
vention, and the latter [illegible]
[illegible] design. [illegible] be pre-
vented [illegible] any proper [illegible]
to be [illegible] from the [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] water [illegible]
[illegible]
[illegible] the occurrence of these
accidents universally, is quite
impracticable, but it may be
reduced to the lowest possible
limit, and the evil may be modi-
fied by a judicious application
of [illegible], or even by
the [illegible], which
might be [illegible] with water
and [illegible] can be prevented
[illegible] places, or
water [illegible]
[illegible] the few cases where
[illegible] have been [illegible] inex-
plicable, but I have no doubt,

[illegible] with the value [illegible] the necessity of removing [illegible] outside of the Embankment from local inundations or cuts made into the [illegible] natural drainage, [illegible] there is no necessity for [illegible], and [illegible] repeatedly [illegible] to [illegible].

[illegible] admitted [illegible] Canal [illegible] having been [illegible], and the details of [illegible] Branches having [illegible] the plan [illegible] followed in [illegible] down the [illegible] used [illegible] rising water [illegible] should be [illegible] would [illegible] supply [illegible] report [illegible] required [illegible]

[illegible] Canal road
[illegible] do.
[illegible] do.
[illegible] do.
[illegible] at the [illegible]
[illegible] of the Ganges
[illegible].

[illegible] required [illegible], to adopt the [illegible] of the [illegible] and ~~[illegible]~~ ~~[illegible]~~ Ganges, to [illegible] of water [illegible] the [illegible] supply [illegible] occasionally furnish ~~[illegible]~~. [illegible] considerations [illegible] XVII [illegible],

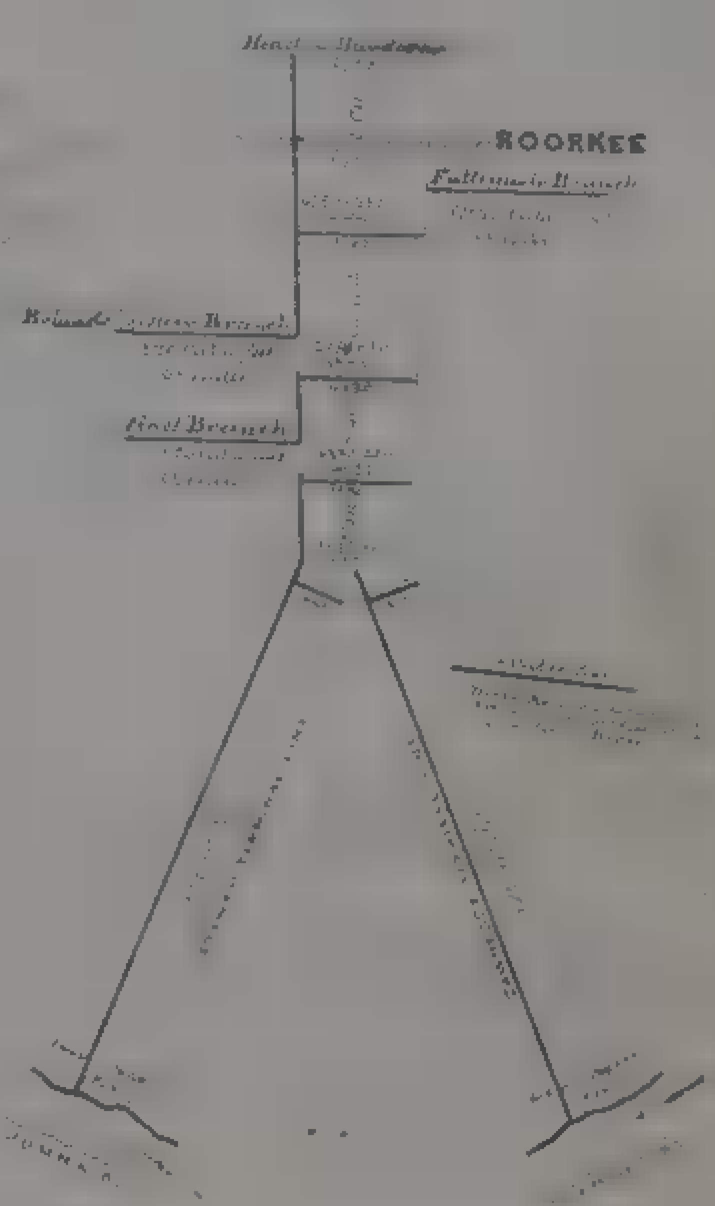
a [illegible]

and it was upon this design that the Ganges Canal has been excavated. [illegible] operated, and takes its place [illegible] at the head of the [illegible].

Diag. CLXIII

Project of 1850

Diag.



The practical operations were conducted on two different plans, in one of which the excavation was carried [illegible] by contract, in the other by [illegible] labourers paid by the work or day under the superintendence of [illegible] officers. ~~[illegible]~~ The first was the [illegible] most generally adopted, although the latter has in many cases, especially in the lower sub-divisions of the main Canal, [illegible] been very conveniently brought into requisition [illegible] employed [illegible] resources of the [illegible]

resources of the country in which the works are situated.

In the Punjab and more especially in those tracts of it lying on the frontiers of the North West Provinces, between the Sutlej and Jumna Rivers, the excavation of tanks and watercourses has from time immemorial been a trade carried on by a class of people, nomad in habits, who attach themselves to any locality where work is plentiful and where, from the absence of restriction to grazing, their cattle can be allowed to wander about without interruption from [illegible]. This class of people who go under the name of "Oads" may in their habits be compared to the gipsy clan in Europe, pitch their tents on the roads, selecting spots for their habitations [illegible] in the neighbourhood of a well for drinking water. [illegible] in character the tents of the gipsy, pieces of [illegible] stretched on a pole, [illegible] or sticks, a species of matting made of grass, or [illegible] covers of [illegible] composed of any sort of material that is at hand, constitute the residence of an "Oad"; and with his women, his cows, goats and donkeys, the latter being the staple of his trade, he appears to have as much happiness and comfort as the denizen of civilized abodes, is quiet and tractable, and [illegible] by occasional forays into the cultivated tracts, leads a life of [illegible] appearance, well regulated [illegible] with no one, and [illegible] wants beyond [illegible] animal sustenance, as [illegible] independent as the gipsy

[illegible] investigations
that have been made [illegible] the Indian
contracts [illegible], people
[illegible] collected [illegible]
[illegible], and [illegible]
[illegible] the existence [illegible]
[illegible] to them,
[illegible] and the [illegible]

N.1.545-V2-P3-C

[illegible] Head of the Executive
Office [illegible] have [illegible]
[illegible] employed that their conduct
[illegible] and that the only
cause of complaint, in those tracts
[illegible] was
[illegible] impression, [illegible] which
[illegible]
was in itself [illegible]
[illegible]. The people in fact appear
[illegible] themselves [illegible] their own
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] appreciated [illegible]
[illegible] words. [illegible]
[illegible]
[illegible]
[illegible] trade
[illegible]
[illegible] the trade
[illegible] introduced [illegible]
[illegible] exemplification [illegible]
[illegible] historical [illegible] will
illustrate the character of these tribes
[illegible] class of people [illegible]
[illegible] brought [illegible]
[illegible]
[illegible] outward
appearance [illegible] character [illegible]
[illegible] had been used to [illegible]
and in [illegible] of this
class of people [illegible] the world,
and

and attached himself to an Oade encampment. A love affair in which one of the Oade ladies of the family was implicated, led to a marriage between the lady and the man who is the subject of this presentation. The parties remained for some time in the encampment when it was discovered that both had absconded, the man in question having by some means or other proved that he was not an Oade. The discovery was not made for some days after the elopement and the parties must have proceeded to a considerable distance before any steps were taken; nevertheless [illegible] [illegible] with more judgment [illegible] than [illegible] a [illegible] party [illegible] immediately put upon the track. Both man and woman were brought back, tried without any [illegible], and [illegible] on the spot. The man was [illegible] a bad [illegible] of the Oade's ~~husbands~~ males [illegible] false ~~[illegible]~~ females Oade [illegible] both gentleman and lady in party coats of red black and white, seated them on two different donkeys with their faces turned towards the animals' tails, paraded them through the different Oade encampments, and finally pelted them with [illegible] [illegible] the [illegible] of the [illegible] [illegible] this proceeding was conducted with great gravity, and doubtless to the [illegible] satisfaction and approval of the [illegible] Oades. [illegible] in the [illegible] many instances [illegible] of [illegible] internal [illegible] amongst these people, and [illegible]

the indefiniteness of action. Every [illegible] the eye of the Vaidar [illegible]. The Vadda is very agreeable [illegible] in design of the [illegible] which [illegible] uses, he is frequently [illegible] and [illegible] [illegible], and [illegible] [illegible] to this class of people. The [illegible] digging for earth is almost entirely confined to the Vadds, who does not appear to use other [illegible] [illegible] this class for this purpose. He is improvident, and appears to be satisfied with a mere subsistence; there is [illegible] a matter of indifference, with the nomad habits that he possesses, it is wonderful to see how he will procrastinate his departure from the ground of an encampment if he sees the slightest probability of other work [illegible] at a distant place. In the vicinity of [illegible] months did Vadds encampment [illegible] about the neighbourhood of the Tillam Branch Road [illegible] [illegible] of the [illegible] being [illegible] upon, and [illegible] that whatever difficulty there may be in collecting the parties in the commencement of a contract there is an equal disinclination on the Vadds part to leaving it until completed. This however, is confined entirely to the earth work upon which the [illegible] these provinces have been undertaken. In the Southern Divisions [illegible] [illegible] works, the name of the tribe as [illegible] is unknown; The Vadd loves not the regions of towns and cities or the proximity of agricultural industry; his fields are those

where

where his goats and donkeys can feed unmolested, where he can enjoy fresh air and drink pure water. The tribes appear to depend in their accounts on a man elected from the Jatha or Bunnia class, who makes them small advances, and arranges the distribution on settling day: this appears to be universally the case when the Oades are working in large bodies, but when detached, or engaged on works in small bodies, the settlements are made without the intervention of a middle man, the contractor placing a confidence in the [illegible] made by the European Engineer, whose decision in all cases is relied upon as a point not to be disputed. With this simple class of people no written contract is entered into, and I am not aware of the [illegible] being [illegible]; at least these people on the Eastern Jumna Canal were [illegible] during my own superintendence as contractors in this class, nearly all the earth portion of the earlier 110 miles of the Ganges Canal works, was done by the same people, many of them being of those who had acted as contractors for me on the Eastern Jumna, and I can speak fully of their habits as orderly and quiet to a degree that could hardly be understood by those who have been in the habit [illegible] to have in any way been connected with European excavators.

Besides the Oades there are numerous other classes of excavators whose occupation

[illegible]

however does not appear to be confined to Aragons, in such a large body of workmen and all the various classes are represented, with more or less benefit to progress. Reference will be made to them in the detail of excavation.

Daily and Monthly Labor have been chiefly employed in detached works in the Northern Division for excavations for masonry works, and in the [illegible] District to parts of the Canal Channel. In making use of these classes of labor, however, task work is demanded, that is to say each man or each party of men are bound to do a given quantity of work, a failure in which leads to a reduction of pay. An able bodied man is supposed to excavate 83.33 cubic feet per day. Cost of this class labor is dependent on the locality, & other instances to which the task has been subjected, & shall enter on this subject more fully presently. As a rule there can be no doubt that [illegible] especially that in Embankments is better done by Daily Labor than by Contractors the former is cheaper in its original cost, but when embankments of made earth are concerned it is [illegible] in the end cheaper.

With these prefatory remarks, I shall enter upon a description of the Canal Excavation, separating it into sections or districts, due to the quantity of the soil with which we have had to contend. And then I will also the divisions which I have enumerated hitherto, applicable to the natural divisions into which the description falls.

the usual Divisions consisting of shingle to the north, sand in the centre, and clay in the lower regions over an abstract a statement of the nature of our Excavations; these with modifications due to local causes give us the following.

Section I From the Head to Roorkee

A. Supply Channel from the Ganges to Myapoor.

B. From Myapoor to the Puttri Supply passage.

C. From the Puttri supply passage to the Rutmoo River.

D. From the Rutmoo River to the [illegible] Falls.

A. Supply Channel from the Ganges to Myapoor

This Excavation consists of a channel excavated through the bed [illegible] of the Ganges, from a point above the [illegible] at Hurdwar to the regulating bridge at Myapoor; it includes also the [illegible] excavation in the neighbourhood of the Myapoor works, and on the [illegible] side of the channel, the construction of bunds, with a quantity of [illegible] intended for the purpose of raising the water from the main Ganges. This excavation is entirely in shingle and boulders, many of them of large size, and [illegible] being completely imbedded; the work is difficult and expensive, and very destructive to tools. The length of excavated channel from the

Ganges

Ganges to the Mayapur Regulator is 14750 feet; its width 300, and its average depth 7½ feet. The slope of bed is equal to 8.59 feet per mile.

From the Dam to its down stream side, a cut of similar proportions and slope of bed to that above described, also excavated in shingle had ~~also~~ been completed, and ~~been~~ the extensive clearances in the neighbourhood of the works incidental to the excavations of the Regulating Bridge, ~~were~~ were done partly by contractors and partly by daily people. The rates vary considerably dependent on the position and depth but they average on the whole Rs 4.5.1 per 1000 cubic feet. The maximum being Rs 6.6.5 and the minimum Rs 5.5.10, when daily labor was used. The rates to contractors per 1000 cubic feet were [illegible]. It may be noted that between the sides of the head bank, in which the Guard Ghat was formerly situated and ~~to~~ the Regulating Bridge, a distance of 350 feet, the excavation on this line was through an upper bed of a very tenacious clay, with thick strata of boulders, the total depth being 21 feet.

B. From Mayapur to the Entrance of [illegible] Passage

The excavation in this line was the first that was undertaken on the Ganges Canal works. It was commenced on the 16th April 1842 on which day the first ground was broken. The work was taken up by contractors of a variety of descriptions, the greater number of the

the class which I have above mentioned under the name of Cades it was distributed in lengths of 25 feet, and the rates were fixed at

From surface to 3 feet in depth @ Rs 2.00 per 1000 c. ft
" 3 feet to bottom [illegible] @ [illegible] per do
Boulders or Shingle at any depth " 3.00 per do

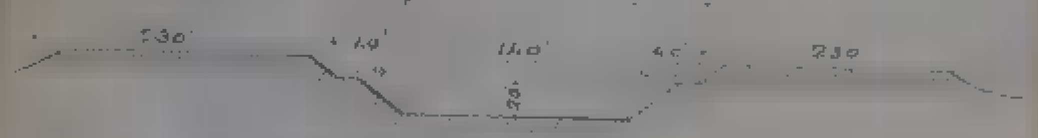
*<

With the exception of the tract immediately in connexion with the Ranipoor Torrent which was [illegible] the line from the Myapoor Regulator consisted of a subsoil of a good firm clay uninterrupted to the neighbourhood of the Ranipoor Torrent; from [illegible] to the Puttree it became more mixed with sand, with occasional traces of shingle thrown in detached patches. The subsoil throughout was sandy, although for the last [illegible] miles of its course, as far down as the [illegible] of the [illegible] at [illegible] the excavation in the lower 5 feet was through heavy shingle.

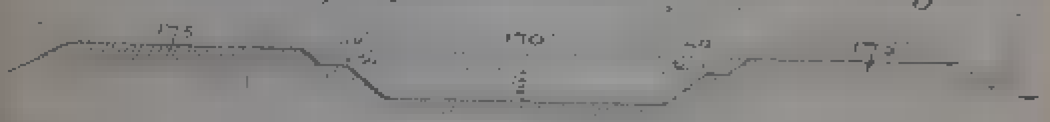
On this [illegible] of which the sections were as follows:

Diag: CLXIV

From Myapoor to the Ranipoor Torrent. Fig: I



From the Ranipoor Torrent to the Puttree Works Fig II



no spring water was met with, the average depths on Figure I may be estimated at 12.6 feet

and the maximum at 15.08 feet
minimum 4.8 "

On Figure II the average depth was 16.3 feet
maximum 21.75 feet
minimum 10.72 – The

*< The excavation was [illegible] under my direct orders by Mr [illegible] Wright an Assistant Executive Officer who died in 1846 after doing most [illegible] service. Capt Richard [illegible] Engineers however who was [illegible] to the Executive charge of the [illegible] the Northern Division [illegible] of the organization of the [illegible] & of placing the works on a [illegible] & [illegible] this tract [illegible] order which ultimately [illegible] is due to the indefatigable [illegible] and well known talent of [illegible]

The rates per 1000 cubic feet were as under, stated from the following table.

From Mayapoor to Ranipoor, per 1000 Cubic Feet – earthwork average	2 14 2
From Ranipoor to Puttree, per 1000 Cubic Feet – average rate	2 " 10

C. From the Puttree superpassage to the Rutmoo River.

This is perhaps the most interesting line of Canal that has been excavated; it embraces the whole of the drainage which as I have explained in the early part of this paper, depended on the retroposition of the Falls, so as to enable the Puttree torrent to be passed over instead of through the Canal. Its whole length is equal to 10810 feet. Of this distance it passes through a ridge upon which the villages of [illegible] are situated, and with the exception of the superposed [illegible] depth of 20 feet [illegible] is entirely excavated through earth impregnated with springs.

I have in the 1st Chapter under the head of superpassages described the arrangements that were made at the Puttree superpassage for enabling the masons to work on the lower levels, being 17.21 feet below the surface of the spring water; the plan that was adopted there, was pursued on the line of excavation which I am now describing, the work was tedious and very expensive, it required, moreover, the constant vigilance of an active supervisor, to see that what was done in one day, was not by the action of the springs undone the next. The nature of the country

through

through which this digging was needed was that of the Canal, before explained, the spring water which in the "Bhabur" belt is kept down by impervious upper strata, rises immediately it escapes from its bondage. At the Baushahpur nulla which is situated within 6000 feet of the Rutmoo, and which is intersected by the Canal, water runs in a perennial stream. The difficulties of excavations this portion of the Canal may be comprehended by referring to the stream in question, which eventually runs on a level of 8-10 feet above that of the Canal bed. This nulla was merely an external exhibition of the spring level throughout the whole line of country to which I am now referring.

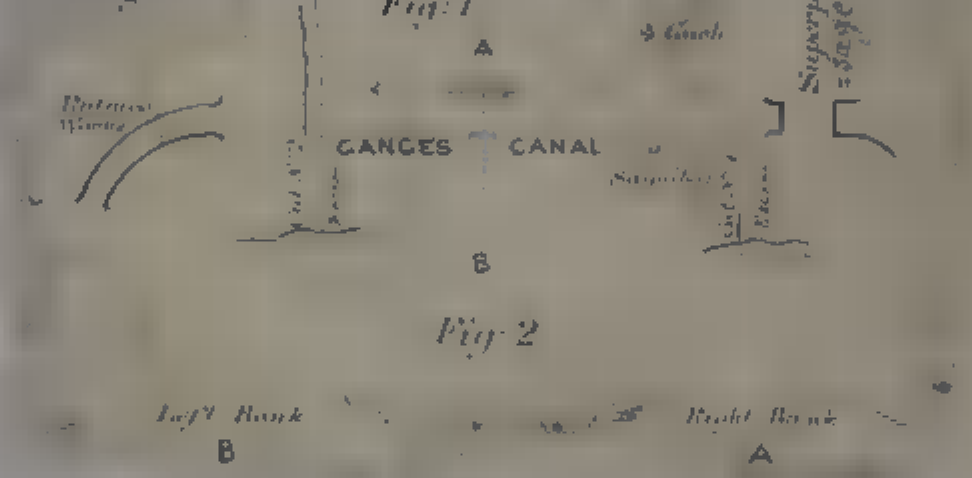
On the excavation in the Pathri [illegible] drainage works, it will be recollected that advantage was taken of the fall of country at right angles to the Canal alignment, to carry a ditch from the Canal in the direction of the slope, so as to give an escape to the water as it collected in the excavations; the effects of this escape were in the highest degree satisfactory; under ordinary superintendence, it would have been useless, with the energetic supervision that it fortunately had, it was maintained in an open state throughout the progress of the work! It was this fortunate arrangement that enabled the officers under whom the work was executed, to make any progress at all, the determined opposition of the spring water in sand [illegible], could only be overcome by the most minute

vigilance

vigilance, and by the constant application of remedies.

After removing the supersoil on that unconnected with springs an excavation similar to that which was executed near the Puttri works, was made near the Baushahpoor Nulla. The distance from the Puttri to this nulla is [illegible] so that by making use of the Baushahpoor Escape for the relief of spring water during the excavations, a considerable [illegible] was available [illegible] of the spring current [illegible] North & South [illegible] the Canal [illegible] at right angles [illegible] plan of operations will be best understood by diagram [illegible]

Diag: CLXV



The line [illegible] of the Canal to its full depth is represented by the dots; the way that this was [illegible] may be understood by the diagram C which represents a [illegible] in this case a catch drain for the spring water which flowed in the direction of the arrows. This [illegible] was carried along the whole line of excavation and the [illegible] to the Escape No 2 [illegible]

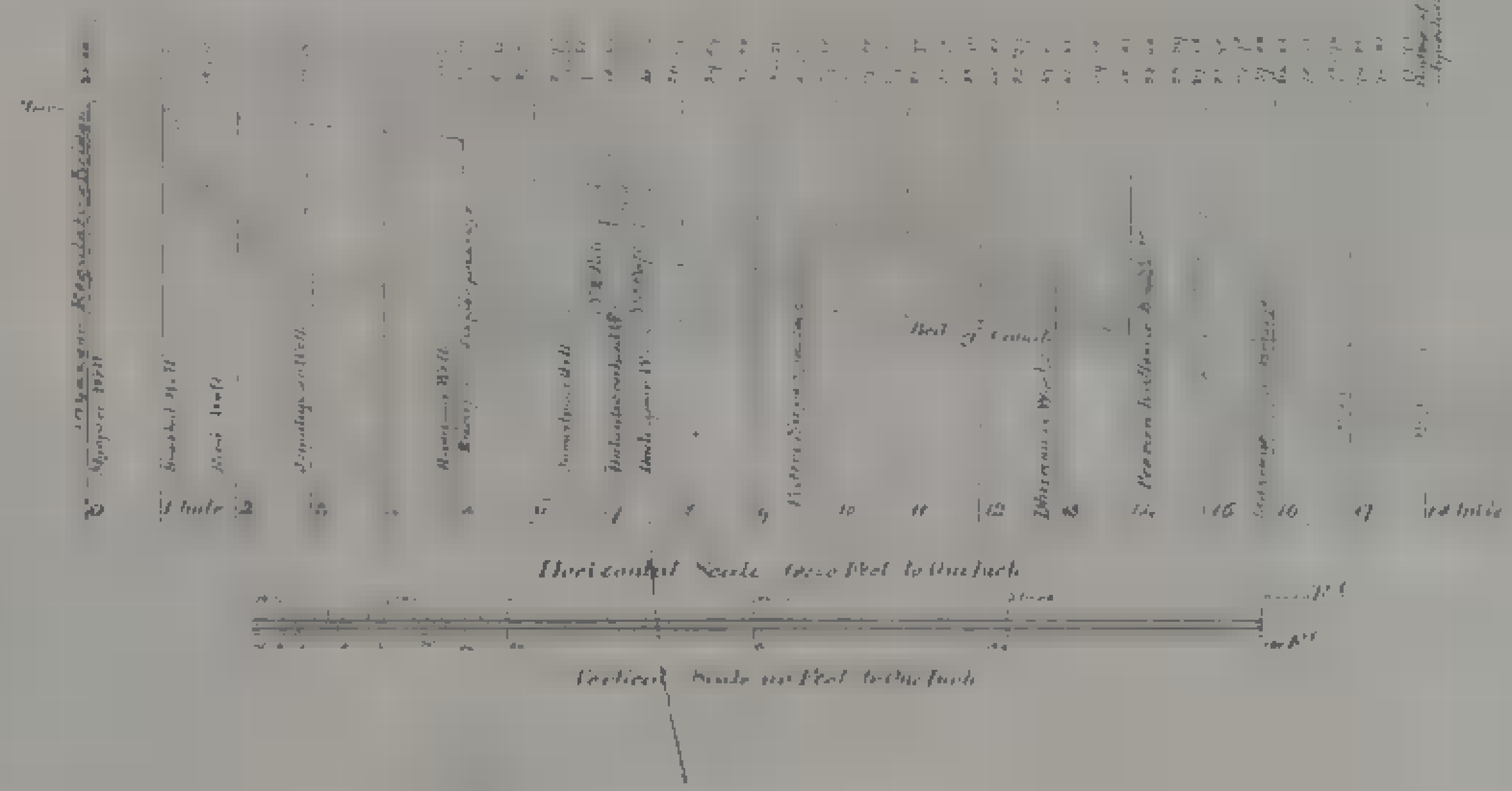
[illegible]

cunette and Escarpe were main-
tained in a constant state of ef-
ficiency as regards the free run
of water. By the interposition of
the Cunette C, that portion of the
canal channel at D was [illegible]
led without trouble, as it was
intermittent of [illegible] its spring &
supply; the process was a very
gradual one, as the depth of the
cunette was increased so did the
portion D become relieved of its
difficulties; it was an operation
requiring especial care, and in a
financial point of view the
greatest attention to prevent the
work of one day being [illegible] also
by the action of springs during
the night time. [illegible] was
[illegible], and [illegible]
[illegible] one of the most
satisfactory works on the canal.

The section of the [illegible]
[illegible] figured on the opposite
page, shews the lines of the springs,
[illegible] from [illegible]
[illegible] to this I would especi-
ally draw the reader's attention;
[illegible] observe however that be-
tween the Cutting and the [illegible]
the maximum depth below the
surface of the country was only
7 ft 20 feet whereas the depth of the chan-
nel to be excavated was equal
to 27 feet. The greatest depth of
digging at the [illegible] ridge was
42 feet, but this extended for a
short distance only. The soil is
more or less sandy although [illegible]
[illegible] clay which [illegible] from
the excavations and the [illegible]
[illegible] at the Cutting [illegible]
in narrow irregular strata with
[illegible]

CLXVI

Section of Northern Division, showing Depth of Spring Water



out any estimate.

The work was done partly by monthly paid labourers, and partly by contractors on rates as specified below.

Mdea

Average	2.6.0	per 1000 cubic [illegible]
Maximum	[illegible]	do.
Minimum	1.14.0	do.

D. From the Rutmoo river to Roorkee on the high land of the Doab.

The valley of the Rutmoo which is about one mile in breadth rests its right boundary on the Peeran Kullear ridge. This ridge which is 2 miles in width comes in contact with its southern boundary with the [illegible] of the Solani valley over which the great aqueduct is constructed. The aqueduct delivers the canal at Roorkee, at which point having entered on the high land of the country it may be considered to have passed its difficulties.

The description of the works of the Solani aqueduct, including the embankments, the earth formations which has been procured in a great measure from the Peeran Kullear ridge, is entered in a separate chapter; the subject of the present section relates mainly to the embankments lying in the Rutmoo valley between the Peeran Kullear ridge and the right flank of the Dam on that river, with general remarks on the ridge digging. The embankments here alluded to were partly made from earth taken from the outside [illegible]

duly

dug to a depth of 2 feet and partly although in a much greater degree from the ridge; the former being done by contractors and the latter by monthly paid labourers who were employed in wagons running on tram roads or rails in carrying the soil excavated from the high land to the lower levels on which the embankments were formed.

The section of the canal on these embankments is as follows.–

Diag: CLXVII

the right embankment being made of additional height and width and both of them on their approach to the Peeran Kulleer bridge having been laid out on extended dimensions.

The depth of channel digging to gain the true canal levels, did not exceed 6 feet, the banks thereof have been a very important part of the undertaking. They have been well consolidated however, and their proportions are on a large scale.

The average cost per 1000 cubic feet was

Maximum Rs 4.. 3. 8
Minimum Rs 1. 10. 6

Although the rates of excavation in the Peeran Kulleer bridge will be explained in detail when describing the aqueduct works, it may be noted here that the depth of digging in its maximum dimensions was equal to 37 feet.

the

The cutting is just through this ridge with the exception of a hollow near its southern limit, averaged in depth 31 feet. The soil consisted of parallel strata of sands and clays, perfectly horizontal and corresponding with those on the opposite side of the Solani valley. There were clear traces of a superficial deposit probably of great antiquity, overlying an ancient surface marked occasionally by depressions, in all probability lines of drainage. This cutting was most remarkable for a stratum of blue clay 3 feet in thickness like that which is commonly found in old tanks and reservoirs, connected with one of a reddish sand deposit with traces of carbonaceous matter exhibiting themselves in form and appearance not unlike those connected with the lignite deposits so commonly found in the Siwaliks. Although a portion of the excavation, especially that near the village of Peeran Kulleer was done by Excavators on Contract, by far the greatest proportion of the earth was carried either to the Kutmore or to the Solani Embankments by Railway. The cost per 1000 Cubic feet in the first case may be estimated at Rs. 3.0.5. That on the railway work runs through variations depending entirely on the distance to which the earth was carried, the average on a great number of rates, giving a cost of Rs 3.11.-/ per 1000 Cubic feet of excavation.

Section II. From Roorkee to the Nanoon Regulators

A. From the Aqueduct at Roorkee to the 110th mile

B. From the 110th to the 180th mile

A. [illegible] line of digging as passes through the Saharunpore, Muzuffurnuggur and Meerut Districts was [illegible] simultaneously [illegible] nearly [illegible] [illegible]. The [illegible] was organised in the [illegible] manner [illegible] [illegible] [illegible] and completed [illegible] [illegible] [illegible] Excavation. [illegible] [illegible] was released [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The rate allowed to the contractors (one) in the first instance from 2 to 2½ Rupees (?) [illegible], was gradually settled down to a fixed standard on which the work was carried to completion. [illegible] standard rate allowed for a canal, [illegible] [illegible] [illegible] was 150 feet, and depth 10 feet, was [illegible] Rs 1.4.0 per 1000 cubic feet, [illegible] depth [illegible] 10 feet the rates were fixed at Rs 2..4.0 per 1000 cubic feet. The earth in all cases had to be carried on an average to a distance of 150 feet.

[illegible] [illegible] [illegible] [illegible] was [illegible] [illegible] was [illegible] contractors [illegible] [illegible] [illegible] a [illegible] of [illegible] 300 feet in length of the Canal [illegible]

[illegible]

[illegible] have been worked to [illegible] labours in Subordinate [illegible] at Rs 1.8.0 in the [illegible] above mentioned and at Rs 1 [illegible] to Rs 2 [illegible] per 1000 cubic feet in the [illegible] (the contractors finding the tools, [illegible] and baskets) for the [illegible].

[illegible] excavation [illegible] 250 cubic [illegible] feet [illegible], and [illegible] annas [illegible] 2 annas each [illegible] more than 10 feet in depth.

>* On [illegible] contract.

There are [illegible] curves [illegible] the [illegible] Solani Aqueduct; this curve is described of a radius of 6617 feet. It is necessarily abrupt from the [illegible] relative position of the Aqueduct to the direct line of [illegible] channel, [illegible] its concave or right bank has been protected by a masonry Revetment. The Libe[illegible] Curve is a gradual one of a radius of 57456 feet; those from Bahadra to Jauli are on radii of [illegible] 30 feet, that at Salawa 4 miles ~~feet~~; and the great curve to the south which brings the Canal to bear upon the Country lying between the Hindun and the Kalinadi Rivers may be described as a Polygon* with the corners cut off by curves ~~or~~ of from 3 to 5 miles in length.

The Subsoil throughout the

>* The actual rates at which this portion of the Canal channel [illegible] excavated were as follows.

From the [illegible] Aqueduct to the 50th mile, the rectangular channel being 140 feet in width the rates were 2 Rs per 1000 Cu feet to a depth of 10 feet from the surface below which the rate was raised to 2 Rs 8 annas.

From the 50th to the 86th mile inclusive the rectangular channel being 130 feet in width the rates were 1/14 and 2/6 under the same instructions with regard to depth.

From the 86th to the 105th mile inclusive, the rectangular channel being 120 ft in width the rates were 1/8 as per 1000 Cu ft.

From the 105th to the 110th mile inclusive the rectangular channel being 110 ft in width the rates were 1/8 as per 1000 Cu feet.

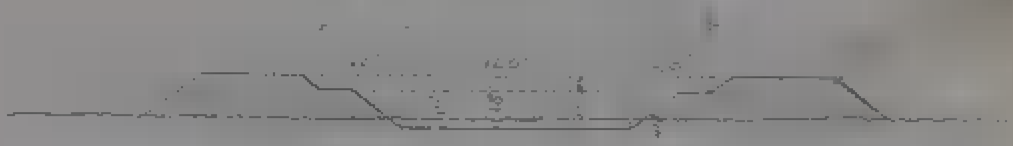
in whole of the country from Nudia to the 116th mile consists of clay underlying sand to a depth of [illegible] deep strata. The clay varies [illegible] [illegible] [illegible] the surface of the country is marked by sand ridges which appear most frequently between [illegible] and [illegible] as well as on the [illegible] Bank of [illegible]. These sand ridges appear again in great part of the [illegible] of [illegible] [illegible] water was met with in excavating the canal channel [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] characteristic [illegible] [illegible] the whole of this [illegible] [illegible] [illegible] was an [illegible] [illegible] sandy. [illegible] [illegible] [illegible] sand [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] at great depths the excavation on the [illegible] may be considered easy, and progress was carried on without [illegible].

There are 2 points on this [illegible] where the levels of the Canal have [illegible] [illegible] depressed below the surface of the country that it has [illegible] necessary to raise embankments to confine the canal [illegible]. The [illegible] [illegible] [illegible] may be [illegible] by the [illegible] [illegible] [illegible]

Diagram

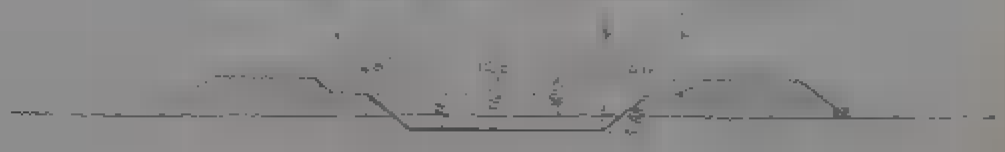
Diag: CLXVIII

Section of Canal at Toghulpoor



Diag: CLXIX

Section of Canal at Meeradnuggur



The diagram [illegible] represents [illegible] the [illegible] [illegible] which is made [illegible] with [illegible] [illegible] watered [illegible] in layers [illegible] 2 feet in thickness. The embankments are situated at Toghulpoor and at Meerad-nuggur [illegible] the [illegible] [illegible] the [illegible] is equal to 1400 feet, [illegible] latter to 700 feet. The earth required has been obtained from the [illegible] excavations [illegible] the [illegible] [illegible] and [illegible] to [illegible] them across [illegible] as at the Toghulpoor and Meeradnuggur bridges, a deposit of material has been made upon [illegible] [illegible] [illegible] [illegible] situated on the [illegible] [illegible] [illegible] by the bridge [illegible] and the canal embankments. As the greatest care has been given to the construction of these works, I do not consider that they will lead to disappointment. I am not quite satisfied with the outside [illegible] from which the Earth has been taken. They have [illegible] however existed for some years without [illegible] [illegible] [illegible] and it is therefore [illegible] that [illegible] the absolute nature of the soil the water that would otherwise [illegible] [illegible] rapidly [illegible] up. If [illegible] [illegible] [illegible] be allowed [illegible] to be carried into the canal [illegible] [illegible] [illegible] which [illegible] have [illegible] [illegible] [illegible] should [illegible]

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Part iii

[illegible] nullas, [illegible] which being the drainage outlets in the way which has been laid down, a [illegible] must be [illegible] constantly [illegible] with the [illegible] levels along the [illegible] of the [illegible] by the right and left. [illegible] system which [illegible] a reticulation of water courses over the surface of the country with its completing drainage and [illegible] of the natural water [illegible] that [illegible] its effects are shown, it appears to me to be [illegible] to lay out drainage outlets [illegible] such as are indispensably necessary for present purposes.

The excavation of the [illegible] at [illegible] [illegible] nulla, and [illegible], was carried out on the same [illegible] of the main [illegible] [illegible] rates were reduced to Rs 1.8.0 per 1000 cubic feet.

The rates of [illegible] [illegible] may be understood from the following Table taken from the Bills [illegible] by the [illegible] Executive [illegible] [illegible] charge of these works.

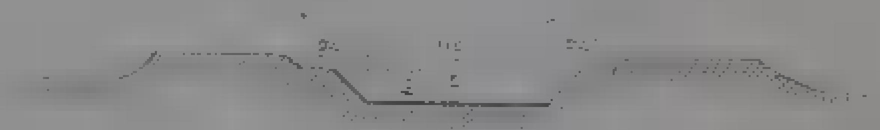
By whom Executed	Site and Locality	Rate per 1000 Cubic feet
Lieut. W. [illegible]	From 2?th to 20th mile	2 4 3
" E. Fraser	do	2 - 11 9
" do	do	2 1 2 5
" do	" 20th to 110th mile	1 15 10 1
Mr Forbes	" do	1 15 0 6
do	do	1 15 -
do	" 5th to 20th mile	2 - 11
do	" 20th to 110th "	2 - 4 3

B. From the 110th to the 160th mile or the [illegible] Regulator.

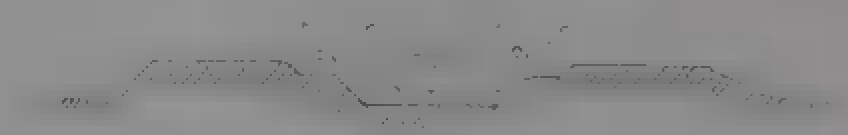
The Excavation [illegible] was [illegible] under the [illegible] [illegible] of [illegible]

The Changes [illegible] the dimensions of the Canal in these [illegible] are shown in the following Diagrams.

Diag. CLXX.
Section at the 110th Mile



Diag. CLXXI
Section at the 1[illegible]0th Mile



Etahen

The tract [illegible] through the Central [illegible] of the Allyghur District. The soil is of a [illegible] description than that of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with the Canal bed. The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] contact with [illegible] [illegible] [illegible] [illegible] portions of the Allyghur District, cultivation is [illegible] [illegible] springs were not met with in the excavation of the Canal Channel, although [illegible] the block foundations at the [illegible] Falls, [illegible] come in contact with them at a depth of 9½ feet below the level of the Canal bed. As a general rule the soil is better [illegible] than it was in the [illegible] from [illegible] to the 110th mile.

The [illegible] cultivated state of the country [illegible] acted as a [illegible] to the [illegible] [illegible] [illegible] [illegible]

[illegible]

work under the Bolt. They carried on progress up to the head of his Division in prosecution of the work which they had begun under Mr. Read, but they refused to commence a new series under the difficulties offered by cultivation to the maintenance of their cattle. The only part of the Bolt's operations thus far, were prosecuted under many interruptions, but of a nature so similar to those that I met with in establishing the works in 1848 at New Dock, that I cannot do better than describe them in his own words.

"At the beginning of the excavation of the 2nd Division, that is, that of Laird Dam, considerable difficulties were experienced in procuring contractors and laborers, although previous to the commencement of the work many parties had forwarded applications for contracts. The cause of this hanging back was said to be dissatisfaction with the rates and the hope that by delaying, more favorable terms would be offered. Several parties that had actually commenced work left the ground, declaring that they could not continue to work at a loss.

"Several months passed away, during which time I continued working with small parties of daily laborers, which mode had a beneficial effect in convincing the contractors that their intriguing would not prevail on me to raise the rates. Finally work commenced under contracts

"The rates for excavating 1000 cubic feet vary from Rs 1.8.0 to 2 Rupees, according to the nature of the soil, the depth of Canal, and the distance to which the earth is to be carried. For this sum the Contractor engages to dress the slopes, to form [illegible] banks, to make all the requisite drains (turnings out), to excavate the boundary ditch, to make a road along the Canal as far as his contract extends, and to keep the same in repair until his accounts are closed and settled.

"No advances of money were given; monthly once or twice payments were made for the work executed, keeping 1/5th to 1/4th in hand as a security, which was paid on completion of the [illegible] on the part of the contractor.

"The contractor has to furnish his own tools, and keep them in repair at his own expense."

"The natives who have been employed in Contract work, were of all denominations, many of them taking up long lines, the maximum extent of any one Contract was equal to 2 miles, the minimum to 100 feet. The work has been very neatly executed, although there appears to have been more trouble with Contractors of the sort engaged on this line, than there was with the Bildar Excavators. In all cases of contract, moreover, written papers were signed and sealed before the work was begun, and upon the due fulfilment of these agreements the work was accepted."

Throughout this line the [illegible] towing path has been formed on [illegible] and with reference to the Canal bed. Where the natural surface was too high, the superfluous soil was removed; where too low, soil was added to it. The whole section is on one uniform design, without the irregularities that have been assumed as existing in the tracts below Roorkee, and as far as the 111th mile where the nature of the soil and the extreme depths to which the excavations were necessarily carried, were opposed to a perfect uniformity of measurements.

From the 156 to the 179th mile a good deal of embanking has taken place, the necessity of which will be understood by a reference to the longitudinal section. The earth required for these embankments has been procured by excavations [illegible] on the outside of the Canal boundaries, to an extent equal to the cubic content of material required, the depth of such [illegible] being [illegible] to the rules of superficial digging. [illegible] an object was to make these [illegible] as deep as possible without proceeding beyond that due to the above rule. The depths, however, do not exceed 10 feet, which it is supposed will be sufficient for the [illegible] to prevent the growth of water plants. It is proposed also that these [illegible] plantations would

be considered a part of the conservative duties of the Division, that means shall be taken for keeping them filled with water from the Ganges Canal heads, and that they shall act as supplies for a [illegible] irrigation to the lands lying on their borders. There was a choice between two evils, either by taking a deep [illegible] cut from the [illegible], by which the carriage of material to the banks would have been enormously expensive and a very extensive depression of [illegible] would have been caused [illegible] areas [illegible] [illegible] inundation during the rainy months [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] would have been [illegible] the [illegible] of the [illegible] [illegible] [illegible] position of the Canal with reference to the [illegible] of the boundary [illegible] that [illegible] [illegible] [illegible] [illegible] duties!

The rates per 1000 cubic feet [illegible] including contingencies are shown in the following table:

Main Canal	1 12 3	per 1000 cubic feet
Distributaries	1 5 [illegible]	"

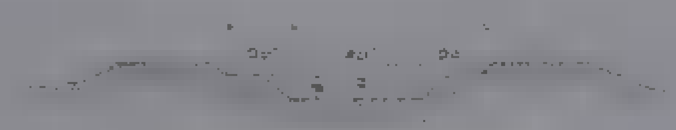
Section III. Cawnpore Terminal Line

The [illegible] of the Canal was [illegible] in the cold weather of 18[illegible] [illegible]

[illegible] [illegible] miles under the management of Lieut. Woodason and the east bank under that of Lieut. C. H. [illegible] of the [illegible]; the work was completed by the [illegible] Tree. The dimensions of the [illegible] its extremes are shown in the following diagrams

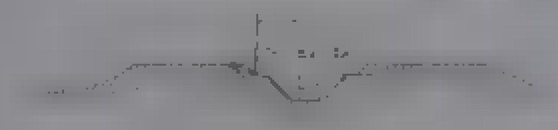
Diag. CLXXII

Section at the Head [illegible]



Diag. CLXXIII

Section at the [illegible] Bridge



The tract of country through which this line is carried [illegible] well cultivated, [illegible] at many parts [illegible] the [illegible] traversed by [illegible] [illegible] those are [illegible] [illegible]. The condition of [illegible] depends in a great measure on the [illegible] [illegible] water [illegible] the [illegible] is [illegible] at these points, although the subsoil is [illegible] without much difficulty. [illegible] [illegible] throughout the whole of this region, it appears to me to be almost universal; [illegible] it is not found [illegible], it is [illegible] [illegible] and as the [illegible] [illegible] [illegible] against [illegible] [illegible] [illegible] The [illegible] [illegible] [illegible] [illegible] required [illegible]

rich manure, although in other respects time only can show how far it will affect the value of the Canal as a Channel for distributing water to the Irrigators. From the observations of the few years that have elapsed since the excavation was made I should conclude that the soil throughout is of a very retentive nature, and that in this respect it will be favorable to economizing the supply.

There appears to have been greater difficulties encountered in the [illegible] than [illegible] in getting Contractors, and in many cases in collecting water [illegible] at all; the former [illegible] undoubtedly from [illegible] [illegible] at a still greater distance from the lands occupied by these people, the latter from the same causes as have been described [illegible] the desire to [illegible] [illegible] Scott [illegible] [illegible] that portion of [illegible] passing through the [illegible] and [illegible] Districts, commenced operations by [illegible] of two classes of irrigation, first [illegible] [illegible] to that of the [illegible] [illegible] [illegible] of [illegible], [illegible] amount of [illegible] per 1000 [illegible] [illegible] [illegible] width of the [illegible] [illegible] varied from 30 to [illegible] feet, whereas the latter [illegible] decreased to a width of 40 feet. It was upon these rates that my [illegible] of 1851 was formed. [illegible] however

which can be best explained in the words of Lieut. Hodgson's own report recapitulated an increase and there can be no doubt that such was ~~[illegible]~~ justifiable. Lt Hodgson writes: "The rate of Rs 1.10.0 per 1000 Cubic feet of Excavation was fixed by me under the idea that Contractors to whom I had given out work were carrying it on without difficulty at the rate of Rs 1.3.0 to Rs 1.4.0 per 1000 Cubic feet for the mere excavation of the rectangular section of the Channel, exclusive of slopes and the final formation of banks, to which I calculated that only a small addition to the rate would suffice. I have, however, since then found out that for a distance of 12 miles throughout which I had been [illegible] the Contractors have been paying their labourers at the rate of Rs 1.8.0 and Rs 1.9.0 for the mere excavation of the rectangular part of the section, and throwing the earth into irregular banks."

"The work being only carried on by means of advances to the Contractors (by which plan alone did I find it possible to obtain them) it was not for some time that I discovered that this had been the case, nor indeed until very lately did I make myself certain of the extent to which it had been carried, and since the discovery I regret to say that work has been [illegible] stopped, owing to the labourers refusing to work at rates [illegible] ordinary ones; indeed no one working at the [illegible]

rates I have no doubt [illegible] usually met by [illegible] [illegible] [illegible] [illegible] have also [illegible]. However, that a rate lower than [illegible] will be accepted by them after the [illegible] of [illegible] being [illegible] no doubt [illegible] the experience in the other parts of the works, yet it is perfectly clear that a larger rate might be allowed them [illegible] only [illegible] and [illegible] especially in all the [illegible] diggings and [illegible] [illegible] [illegible] which in the [illegible] part of the [illegible] yet [illegible] found in a very great extent.

Withdrawn — That in some parts of the [illegible] of the digging the rate, [illegible] will not exceed [illegible] per 1000 cubic feet, but that will be the lowest [illegible] now in several places completing portions including the formation of banks [illegible] [illegible] payments for the latter work [illegible] and making [illegible] have brought the cost up to [illegible] 3d per 1000 cubic feet. To this will have to be added a small amount for planting grass on the slopes and also a percentage for expenses of [illegible] which will leave at most nothing to provide for keeping in good order the slopes and banks previous to the completion of the several [illegible] or portions [illegible] which bills will be submitted. I must also add that [illegible] of the works [illegible] after the [illegible] [illegible] satisfied of the former [illegible] perfectly aware that the [illegible]

have been nothing scarcely, and the latter do not on an average make anything approaching to the usual daily payment to six pence that prevails in the Department of Public Works.— My experience from actual ex-cavation of the work as yet extends as far as the 26th mile to a width at bottom of 57 feet, so that I am only judging of the probable cost of the lower part of the division very imperfectly; but it is seen, that as far as we have yet gone, the rate for 1000 cubic feet has not decreased but on the contrary increased with the dimensions of channel. This can only be accounted for on the supposition that the class of labour required, are more abundant at the head of the Division than in the lower parts. At the same time I find that the proportion of earners to diggers amongst the squads of workmen does not differ in parts 80 feet and 60 feet wide, and it is clear that a very trifling change decrease in the rate can be made for decrease of width of Channel; whilst the cutting away of slopes, the formation of banks and the contingent expenses remain the same for both sections, and consequently bear a much greater proportion to the plain digging in the narrower than in the wide section thereby causing rather an increase than a decrease to the rate as the Canal narrows.—

"The cheapest parts of the digging are the deepest and such are the parts in which I have stated that I am completing work for Rs 1.8.0 per 1000 cubic feet; the reasons of the lower cost in such parts are obvious, these being always in cultivated lands and the harder surface soil and the stratum of Kunkur (invariably to be cut through) bearing a much smaller proportion to the softer under soil, generally in such situations partly sand than in shallower places.

"The 12 miles I have before alluded to are from the 46th to the 58th, throughout rather not exceeding 5 feet in depth and consisting of brown soil mixed intimately with small Kunkur and Bugri all unfit for use from its impregnation with soda. There are also parts where the Kunkur formation is partially consolidated which is very hard to dig through. The latter parts are of course exceptional cases, and the high rates there will admit of explanation. At present no one will dig in them.

"I state then the rates which appear to me sufficient to cover the expenditure;

"From the head of the Division to the 60th mile on the whole number of miles, inclusive of the Embankments in the 26th and 27th miles Rs 1.4.0 per 1000 cubic feet, but that in

some

Some miles this rate will be exceeded and especially in such parts as present practically formed kunkur.—

"Then from the 60th to the end of the Division, 100th mile, considering the great prevalence of the [illegible] soil [illegible] increased rates of contingent [illegible] to the absolute [illegible] the labour of excavation, and also to the difficulty experienced [illegible] in obtaining contractors or labourers by Lieut. [illegible] in that part [illegible] lying [illegible] above my Division, I cannot but anticipate a rate somewhat higher than the above and therefore beg to put it at 2 Rupees per 1000 cubic feet.

"In the above calculations I have taken into consideration the probable value of kunkur as separated from the earth, for which I pay extra per [illegible] if so separated, [illegible] with the value of it.

"I must further add that the contractors who have made payments to the labourers in excess of the sums stipulated for in their agreement [illegible] because [illegible] able to make such sums good and that, therefore, they [illegible] a loss in this part of the [illegible] which [illegible] I can amount to from 700 to 800 Rupees"

[illegible] gives a fair account of the difficulties which occurred in the early part of [illegible] on this [illegible] in the excavation. Lieut. [illegible]

in fixing low rates were deserving of all commendation and although he failed in so far that [illegible] was inevitable, the effects arising from the knowledge that this low scale of rates led to, were undoubtedly favorable to his ultimate progress. After all, the rates which were ultimately used after so much inquiry and experiment were more or less those of my original Estimate which amounted to £[illegible] for 1000 cubic feet.

Borough

Another notable fact in this division was that contracts were taken by men who apparently entered into undertaking work of this sort in their lives, [illegible] perfectly ignorant of the cost of excavation; and who trusted entirely to their luck or destiny for fortunate results. The failure already described by Lieut. Hodgson was a notable example of this speculation, the conduct of these people would in England have been called knavery, and had Lieut. Hodgson who did not take advantage of it would in all probability have been found fault with. Lieut. Hodgson might certainly have left these contractors with their written agreements to suffer the loss themselves but he acted judiciously in not doing so, and his proceedings in this case did in all probability do more towards rendering his board of works acceptable to people, who were by no means ready to give them, than anything else that he could have done. [illegible]

to

in fact who failed on this occasion, succeeded afterwards, and Lieut. Hodgson had nothing to regret in leaning to the favorable side of the question in these early failures.

The rates at which work has been executed under Lieut. Hodgson in the first hundred miles of the Cawnpoor Terminus, will be seen by the following table, ~~which are~~ and considering the difficulties to which I have drawn attention they are very fair and reasonable.

Locality	[illegible]
From 1st to 38th mile	1 11 3
" 38th [illegible] "	1 10 11
" 50th to 75th "	1 6 10½
[illegible]	1 12 9

As a general rule the working or lower features have been maintained on a level parallel with that of the Canal bed. Deviations from this rule have only been allowed in extraordinary cases where a great saving of expenditure could be ensured; in such cases the higher levels were gained by very long slopes the rise and fall of which are almost imperceptible.

From the 100th mile to the Terminus at Cawnpoor the excavation was commenced in the cold weather of 1849 by Lieut. Hutchinson of the Engineers, who on his departure on medical certificate in 1852 made over the works to Lieutenant Hodgson.

Lieut. Hutchinson's arrange-

[illegible]

ry tions were a repetition of those which have been before described, with perhaps additional diffi-culties in procuring labourers. The tract of Country over which his line of works was carried ex-tended through the Futtehpore and Cawnpoor Districts, 26 miles of the former and [illegible] of the latter. The Futtehpore District was very similar to that described as extend-ing in the first 100 miles of the whole of this terminal line, in-terspersed by a good deal of barren and waste land, but highly cul-tivated elsewhere; waste land was not so prevalent in the Cawnpoor District, the greater por-tion of the Channel passing over Country cultivated in a very high degree. Lieut. Hutchinson shall describe his own impressions on the [illegible] which [illegible] with as stated officially to me in a letter dated 1st February 1851

"As regards the excavation of the Canal, you observe that this is a thickly populated District and that therefore we should experience no difficulties in pro-curing men. The Cawnpore District *is* a thickly populated one and it is also most prosper-ous and fertile; the labourers for the most part are well off, and will not leave their fields to work on the Canal; [illegible] have left the District and greater [illegible] divisions of the Canal, with just as the impression appears strong amongst them that the rates there are greater chances of [illegible] [illegible]

[illegible] operation, the rates we started at, Rs 1..2..6 per 1000 Cubic feet, was undoubtedly too low, and the report spread that no [illegible] profit to be made. This completely stopped our works for about, and it was not till the end of 1860 that we may be said to have got over this impression and commenced work at a higher rate. Since then the work has been progressing and improving rapidly with the exception of about six weeks when our works were nearly deserted by the labourers going to cut the harvest crops. Even now hundreds of labourers frequently leave their work to go for a few days to their farms or to weddings, and then come back again. If a days rain falls the works are deserted and it takes a few days to collect them all again. I would beg also to draw attention to the Military Board's circular No. [illegible] dated 7th October 1850 in which the officer of the Grand Trunk road in this District has shown that he finds his earthwork costs him including dressing, Rs 1..6..2 per 1000 Cubic feet, at this rate I could push on work much more rapidly, but I have been endeavouring as much as possible to keep the rates [illegible] my work within my Estimate of Rs 1..6..0.

"I also beg to point out with reference to my rates as compared with the [illegible] [illegible] that when the [illegible] becomes so

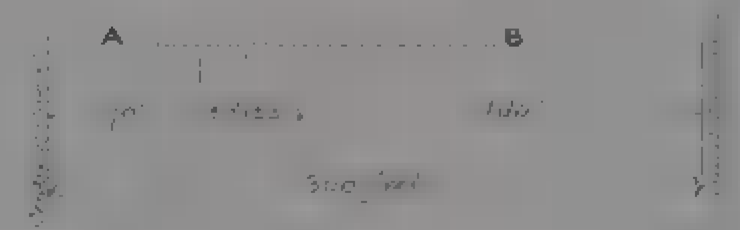
numerous

narrow as it does down here, the quantity of dressing of the slopes remains the same whilst the proportion to the dressing in the rectangle is much increased.

"For example let the rectangular section be 140 × 9 and breadth between the canal boundaries 300 feet.

Cummins

Hammond



the mean distance earth is carried is AB = 172½ feet.

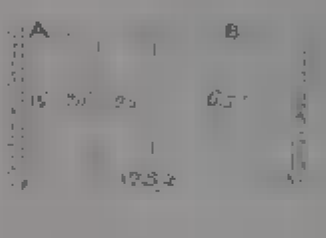
In a mile of Rectangular channel the cubic contents 140 × 9 × 5280 = 6652800

In a mile of slopes 9 × 9 × 5280 = 427680

the proportion of slopes to rectangle being 1 to 15.6.

"If [illegible] be the rate paid for the whole work then 7080480 = Rs [illegible], and if the dressing slopes to cost the contractor 6 annas per 1000 cubic feet more, then 427,680 cubic feet at 6 annas per 1000 = Rs 160.5 [illegible]

"When the average section is as here 30 × 9 and width of canal land 225 feet



the mean distance earth is carried is AB = 62 feet.

In a mile of Rectangular channel the cubic contents 30 × 9 × 5280 = 1425600

In a mile of slopes 9 × 9 × 5280 = 427680

(the same in both cases) the proportion of slopes to rectangle being 1 to 3.3. If Rs 11/6/- be the rate

per

ied for the whole, then 1853280 Cubic feet = Rs 2548.4.0, and supposing the Slopes to cost as much more in this case as in the other viz 6 annas per 1000 Cubic feet then 427680 Cubic feet at 6 anna per 1000 = Rs 160.5.0.-

In the one case the Contractor deducts from his profits Rs 160.5.0 from Rs 1327.14.0 and in the other Rs 160.5.0 from Rs 2548.4.0

There is no doubt that the sloping and dressing is the most expensive part of the work, and my object in making the above rough calculation (which is of course not actually correct as I do not know the rates in Section of the 2nd Division) is merely to show that the quantity of sloping and dressing being the same everywhere, bears a more small in proportion it bears in a broad Section to the mass of digging in which profit is made, as compared with the proportion in a narrow Section. The distance of earth thrown in the first case is double that in the second, but if the rates are as I have calculated them Rs 1/11/4 there and Rs 1/6/6 here, I consider that 5 annas per 1000 Cubic feet is too large a difference for the cross carriage of earth 8 feet. On the first Division I am not certain; if this is as I suppose too large a difference, it follows that the rates there are much [illegible], than they are [illegible] consequence of the greater difficulties of procuring men and contractors that exist

here. As I before stated, however, I think that any difficulties as regards excavation are in a great measure overcome, and I trust that this work will now progress rapidly."

With the exception of the depths of digging in the 2nd Division which is, generally speaking, much in excess to that noted by Lieut. Hutchinson, his comparison is a true one; there is no doubt whatever that the proposition that the expense work in slopes and drains gives to the cheap or rectangular excavation, is a matter of great consideration to a contractor, in that he prefers wide channels to narrow ones on this account. But where great depths, entailing the carriage of earth up steep ascents and up long distances, as was the case in the 2nd Division, were the principal source of expense and difficulty, there can be no doubt that the work was comparatively cheaper; this however arose from the presence of the professional earth contractors, who took to the excavation with a perfect understanding of what he had to do; in the Districts below Alligarh the people who undertook work appeared to be in most cases men who had not been previously engaged in excavation, and were actually ignorant of even the simplest parts of the profession. This led to the necessity of a supervision and watching

for which with the regular Earth contractor there was no need; Contingent Expenses unknown in the 2nd Division were, therefore, heaped upon the original Contract rates. On the upper parts of the Canal, in fact we worked with professedly educated people, in the lower we had to educate them ourselves, and to submit to all the disappointments and expenses attendant thereon.

Before Lieut. Hutchinson left his work in 1852, the greater proportion of the Channel had been excavated, but by his arrangements which were similar to the upper parts of the Canal of separating the contracts for slopes from those for rectangular digging, he left to his successor a legacy which in effect was like that [illegible] to [illegible] in his comparison [illegible] rates. He ~~[illegible]~~ had completed the greater proportion of the unsafe digging or rectangular section, whilst he left to his successor the completion of the slopes or that portion of the work upon which were his comparison above given premiums in addition to his estimated rate of excavation. Although, therefore, Lieut. Hutchinson's Bills as submitted showed that he had done work at Rs 1.7.2 7/ per 1000 cubic feet, and therefore, had worked very closely with his Estimate, he left to his successor the loss of doing the more expensive

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pressure [illegible] [illegible] by the
[illegible] whether [illegible] proportion of
rectangular digging would
have been [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] of [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] have left
incomplete.

Hull

[illegible] [illegible] [illegible] [illegible]
[illegible] constructed [illegible] [illegible] [illegible]
as was adopted [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] made [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] case, [illegible] [illegible]
[illegible] made [illegible] [illegible]

The rates [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] as follows:

Average rate [illegible]		
[illegible] Hutchinson	1 7 7/7	per 100 [illegible]
[illegible]		

[illegible] August 1852, [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
at the following rates

first 25 miles	2 6	per 1000 cubic [illegible]
31 to 65 [illegible]	2 5 8/2	

The [illegible] [illegible] [illegible] [illegible]
rate [illegible] [illegible] [illegible]
1. 6. 3, per 1000 cubic [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]

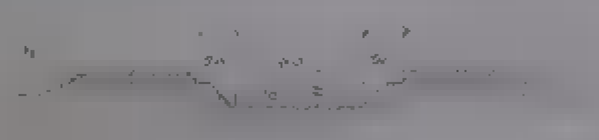
from the nature of the [illegible] stone [illegible] construction, and the use of [illegible] and [illegible] have been [illegible] at 5.0.0 per 1000 cubic yards

Section IV. Etowah Terminal [illegible]

The Excavations on this [illegible], the [illegible] dimensions [illegible] are shown in the following Diagrams

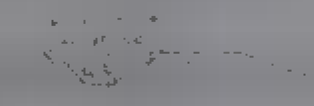
Diag. CCLXXIV

Section at the Head



Diag. CCLXXV

Section at the Tail



B.101.

[illegible] until 1830

[illegible] had the advantage of the experience that [illegible] on the [illegible], the profile too in the [illegible] [illegible] were prepared and some [illegible] for the system that would be [illegible] as well as of the rules that would be allowed, on Excavation. The Executive [illegible] more [illegible] on the [illegible]. The rates which had been fixed in my Estimate of 1830, [illegible] had been determined on [illegible] and Hutchinson, [illegible] the [illegible] of the [illegible] [illegible]

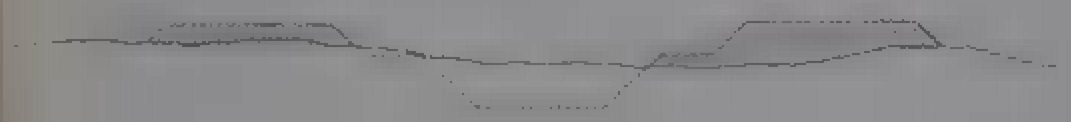
[illegible] 80 [illegible] @ 1/14 per 1000
[illegible] @ 1/10 [illegible]
[illegible] @ 1/6 [illegible]

It will be recollected that for a distance of 65 miles this line runs parallel to and within 6 miles of the Ganges Canal, and that in advance it proceeds through Districts either bordering upon or the same as those traversed by it. The rates of work might therefore be supposed to be the same. On the Canal as on the Ganges Canal the rates given appear to have been insufficient; every care has been taken to adapt them as closely to the Estimates as possible, and from what I have observed I believe that *ceteris paribus* the rates at which the work has been executed on these lines are very good specimens of the true cost of Canal digging, limited to measurements of which the dimensions of the [illegible] are the [illegible].

In laying out the dagwells or lines upon which the excavation was made, it had been usual to fix wooden pins at distances for the purpose of determining the width of the Canal bed, and also that of the embankment; these wooden pins were very subject to disarrangement, they were constantly knocked down by cattle and were generally stolen by the village people; they were moreover especially bad and imperfect guides to the contractor. [illegible] distances the [illegible] pins [illegible], and at every 200 feet in length of the Canal Channel, built up to the mark of the [illegible] and [illegible]

fill above the surface level of the country, in the form of a rib, or former, so that at short distances along the whole line there existed previously to the commencement of excavation the true outline of the Banks and berms as they were to be constructed at that particular point; taking a section of the country there, upon which a contractor was set to work, its appearance was as follows:-

Diag: CLXXVI



The shaded lines drawing, [illegible] in former, the outline [of] that portion of the work which had to be excavated. In proceeding down the line of works therefore, when the excavators had been placed upon them, these ribs exhibited at a glance the amount of channel to be excavated and showed clearly where the [lines] corresponded with the surface, to where embankments and raised towing paths had to be made. In making these ribs or rough marks, a trifling expense was incurred in the first instance, and a good deal of supervision on the part of the surveyor, but they were amply compensated for afterwards by the facilities with which levels were recognized, and the method and order with which the whole work was done. I may observe that the [illegible] in former cases had been

been of solid [illegible] imbedded in the earthwork there [illegible], to [illegible] the top of the pin acted as the true level or bench mark. This plan originated with [illegible], and I consider it to be one well worthy of the consideration of those who may hereafter be engaged in Canal Excavation.

Etawah

The dimensions of the [illegible] are laid out on the same design as those described in the Cawnpore Terminal, i.e. with a few exceptions [illegible] are parallel to the bed of the Channel [illegible] uniform scale throughout.

The soil is very similar to that described as existing on the [illegible] branch to Cawnpore, tracts of [illegible] alternate with richly cultivated land, the latter predominating in the Etawah and Cawnpore Districts. [illegible] both in [illegible], and in places the [illegible] indiscriminately [illegible] soil [illegible] with [illegible]; the soil [illegible] appears to have the same [illegible] retentive qualities that [illegible] notes as so remarkable in the soil of the [illegible].

I have mentioned that the progress of excavation on the Etawah Terminal [illegible] was more backward than elsewhere in consequence of the lateness of the period at which it was commenced. [illegible] inspection, however, in December 1853 the Channel and Embankments had been completed as far as the

60th mile, considerable advance had been made as far as the 110th mile; and work was in progress down to the 130th mile, beyond this no excavation had been commenced upon.

The rates of excavation are shown in the following table.

Locality	Rate per 1000 cubic feet
From 1st to 20th mile	196
" 20th to 40th do	193
" 40th to 60th do	188

In looking at the rates and difficulties of procuring labourers on the Terminal lines it [illegible] that one bearing upon [illegible]; [illegible] also to the [illegible] made by the Engineers on the [illegible] value of the excavation [illegible] [illegible] in wide [illegible] narrow channels, when although the rectangular digging in the one is [illegible] greater than that in the other, the slopes, [illegible] and the more expensive parts of the work are common to both; I will in concluding this chapter remark, that [illegible] the [illegible] excavations of the Eastern [illegible] about three fourths of which were done [illegible] between the years 1826 and 1830, partly by contract and partly by daily labor, the former being undertaken [illegible] by the [illegible] tribes, the latter which was only carried [illegible] the immediate neighbourhood [illegible] the [illegible] [illegible] improvement by the [illegible] of the villages [illegible]

The rates were as follows, and they were determined by the Superintendent of the works on the nature of the soil, and on the facilities for excavation without any reference to dimensions. Where the soil was sand (although the channel was wider) the rate was lower than that when the digging was executed in clay. For instance the fixed rates of contract were from the village of Sukkuri [illegible] to the Jumna at [illegible], a distance of 111 miles, the rectangular width of channel at the two extremes being 30 and 15 feet, 0-1-3-1 per 1000 cubic feet. From Sukkuri upwards where there was nothing but sand although the [illegible] varied from 30 [illegible] in width the rates [illegible] diminishing to [illegible] per 1000 cubic feet, and [illegible] these rates [illegible] to the [illegible]. These contracts [illegible] that the making and [illegible] the embankments, berms and slopes and the contractors accounts were settled until [illegible] equalled 1000 feet in length [illegible], and accepted as such by the Superintendent of the [illegible]. This length of [illegible] was [illegible] up to the [illegible] Regulator and through at least 4 miles of [illegible] digging.

[illegible] that in [illegible] cases it would have been [illegible] to have paid down the money, and to have done the work either by daily labor, or by employing more supervisors to have had a greater check upon the [illegible].

It was quite impossible when the soil was hard, and when it came out of the excavators hands in lumps, to get the lumps beaten up so that the embankment might be properly made. It was wonderful the ingenuity with which bad work was concealed by a superficial coating of well broken up soil. But it was by no means wonderful to see the effect that this bad work had on our after prospects; Beautifully perfect as the sections appeared when given over by the contractors, rainy season after rainy season produced its effects in destroying the slopes and [illegible]. It is a fact that the banks which are now in such excellent order and which often are of the best roads and the pleasantest drives or rides in these provinces, were ten years before they were properly consolidated, and [illegible] the [illegible] of [illegible] the embankments [illegible] settlement may have been [illegible] in the first cost [illegible], there will be [illegible] to [illegible] effect from these [illegible] causes [illegible].

Wilkhier

CHAPTER. XI.

Current Expenses

This Chapter may be divided into 2 Sections viz:

I. Establishment

II. Ordinary Repairs

Section I Establishment

The detail of Establishments as specified in Appendix D (vide Volume of Tables) was very closely observed during the whole of the operations. Where this was departed from, circumstances of a peculiar nature may be traced, as in the Northern Division where the constantly increasing amount of works rendered increase of Accountants necessary, and in the 2nd Division where from want of assistance to the Executive and the necessity for his time being occupied more than usual in Field duties a more highly paid and more efficient head to his Office became necessary. The rules however laid down in the above table were maintained as closely as possible, and the Amount of Establishment then fixed was considered to be the Standard in each Division.

The State of the Establishments during the working period may be understood from the following Tables, which shew in juxtaposition the number of men and amount of pay of each which existed on the 1st January 1843 and the 1st January 1854: [illegible]

the dates exhibiting the two extremes of the working operations, under my superintendence.

1st January 1846

Northern Division

No.	Description	Rate	Amount	Total
1	Ex. Engineer		400	
1	[illegible]		400	
2	do.	250	500	
1	do.		200	
2	Asst. Conductor	65	130	
1	Accountant		100	
1	Clerk		45	
1	do.		40	
1	do.		25	1840
1	[illegible]		30	
1	[illegible]		30	
1	[illegible]		20	
2	[illegible]	15	30	
3	Duffadars	6	18	
12	[illegible]	4	48	
3	[illegible]	5	15	
4	[illegible]	4	16	207
1	[illegible]		20	
1	[illegible]		14	
1	[illegible]		12	46
1	[illegible]		10	
1	do.		6	
1	do.		3	
1	do.		–	
5	[illegible]	4	20	
1	do.		4	53

Total Compy's Rupees 2151

No.	Description	Rate	Amount	Total
1	[illegible]		300	
4	Asst. Overseers	65	260	
1	Accountant		100	
1	Clerk		45	705
1	Mounshee		30	
2	Duffadars	6	12	
8	[illegible]	4	32	
2	[illegible]	10	20	
2	do.	8	16	
2	[illegible]	5	10	
2	do.	4	8	138

Total Compy's Rupees 843

Second Division (1st June 1846)

No.	Description	Rate	Amount	Total
1	Ex. Engineer		400	
1	Asst. do.		250	
1	do.		210	
2	Asst. Overseers	65	130	
1	Accountant		100	
1	Clerk		40	1135
1	Mounshee		30	
1	[illegible] Surveyor		20	
1	Native Doctor		15	
2	[illegible]	15	30	
2	Duffadars	6	12	
12	[illegible]	4	50	
1	[illegible]		6	
2	[illegible]	5	10	

[illegible] Compy's Rs 203 — 1135

1st January 1851

Northern Division

No.	Description	Rate	Amount	Total
1	Ex. Engineer		600	
3	Dy. Superintendent	400	1200	
1	do.		300	
2	do.	200	400	
3	Asst. Conductor	65	195	
1	Head Clerk		150	
1	Accountant		150	
1	Clerk		80	
1	do.		60	
1	[illegible]		25	3120
1	[illegible]		30	
1	Mounshee		30	
1	Treasurer		20	
1	Asst. do.		10	
2	[illegible]	15	30	
4	Duffadars	6	24	
16	[illegible]	4	64	
2	[illegible]	6	12	
2	do.	5	10	
4	Peons	4	16	
1	[illegible]		4 8	
1	do.		4	[illegible] 8
1	[illegible]			20
4	[illegible]	10	40	
[illegible]	[illegible]	[illegible]	[illegible]	70

Total Compy's Rupees 3499 8

No.	Description	Rate	Amount	Total
1	[illegible]		300	
4	Asst. Overseers	65	260	
1	Accountant		100	
1	Clerk		45	700
1	Mounshee		30	
1	Treasurer		20	
5	[illegible]	10	50	
2	Duffadars	6	12	
2	do.	5	10	
14	Burkundazes	4	56	
1	[illegible]	6	6	
6	do.	5	30	214

Total Compy's Rupees 914

Second Division (1st Jan 1851)

No.	Description	Rate	Amount	Total
1	Ex. Engineer		500	
1	Dy. Superintendent		200	
1	Acting do.		220	
1	[illegible]		80	
3	Asst. do.	65	195	
1	Accountant		150	
1	Clerk		35	
1	do.		25	1430
1	Mounshee	30	30	
1	Asst. do.		10	
1	Native Doctor		15	
1	Treasurer		20	
1	Asst. do.		10	
2	[illegible]	15	30	

[illegible] Compy's Rs 115 — 1430

1st January 18[illegible]

Second Division Contd

No	Description	Rate	Amount	Total
	[illegible]		203	1125 ..
4	[illegible]	4	16 ..	
1	[illegible]		22 ..	
1	[illegible]		10 ..	249 ..
1	Carriage [illegible]		15 ..	
1	Do Do		10 ..	
1	[illegible]		12 ..	
1	[illegible]		12 ..	49 ..
4	[illegible]	10	40 ..	
4	[illegible]		20 ..	60 ..

Total [illegible] 1483

Third Division

No	Description	Rate	Amount	Total
1	[illegible]		400	
1	[illegible]	200	100 ..	
1	[illegible]		40 ..	540 ..
2	[illegible]	10	20 ..	
1	[illegible]		20 ..	
2	[illegible]	15	30 ..	
1	[illegible]	6	6 ..	
1	Do		3	
1	[illegible]		13 ..	
1	[illegible]		3 ..	
1	[illegible]		10 ..	
1	Do		[illegible]	135 ..

975.00

Total [illegible] 975

1st January 18[illegible]

Second Division Contd.

No	Description	Rate	Amount	Total
	[illegible]	115		1030 ..
2	[illegible]	6	12 ..	
20	[illegible]	4	80	
1	[illegible]		6 ..	
2	Do	5	10 ..	
4	[illegible]	4	16	239 ..
1	Carriage [illegible]		15 ..	
1	Do		10 ..	
1	[illegible]		12	
1	[illegible]		15	52 ..
6	[illegible]	10	60 ..	
1	[illegible]	6	25 ..	
4	[illegible]	6	24 ..	
19	[illegible]	4	76	215 ..

Total [illegible] 1030

Third Division

No	Description	Rate	Amount	Total
1	[illegible]		500 ..	
1	[illegible]		300 ..	
1	Do		100 ..	
2	[illegible]	75	150 ..	
1	[illegible]		[illegible]	
1	[illegible]		[illegible]	
1	Do		[illegible]	1100 ..
1	[illegible]		23	
1	[illegible]		32	
1	[illegible]		20 ..	
1	[illegible]		30 ..	
1	[illegible]		10 ..	
2	[illegible]	15	30 ..	
1	[illegible]		3 ..	
2	[illegible]	6	12 ..	
21	[illegible]		[illegible]	
3	[illegible]		16	
4	[illegible]	4	16	261 ..
1	[illegible]		15 ..	
1	Do		10 ..	
1	[illegible]		15 ..	
1	[illegible]		12 ..	52 ..
2	[illegible]	10	20 ..	
2	[illegible]	5	10 ..	
2	[illegible]	5	10 ..	
6	Do	4	24 ..	64 ..

Total [illegible] 1577

1st January 1846

Cawnpore Terminal Line — Fourth Division

No	Description	Rate	Amount	Total	Total
1	Exe. Engineer		400 ..		
1	Assistant		200 ..		
1	Clerk		45 ..	1445 ..	
1	[illegible]		24 ..		
2	[illegible]	4	30 ..		
1	[illegible]		6 ..		
1	do.		5 ..		
7	[illegible]	4	28 ..		
4	[illegible]	3	16 ..		
1	do.	4	4 ..	103 ..	
1	[illegible]		10		
2	[illegible]		16	26	774 ..
	[illegible] 1131				
1	Ex. Engineer		400		
1	Assistant		200		
1	[illegible]		200		
1	[illegible]		45	845	
1	[illegible]	10	21		
1	[illegible]	15	15		
2	[illegible]	15	30		
1	[illegible]		6		
4	[illegible]	4	16		
1	[illegible]		[illegible]		
[illegible]	do.		[illegible]		
[illegible]	[illegible]		15	116 ..	
1	[illegible]		12		
1	[illegible]		12		
1	[illegible]		12	36 ..	
1	[illegible]		10		
2	[illegible]	5	10		
[illegible]	[illegible]		[illegible]		
4	[illegible]	4	16	36	1053 ..

Total Company's Expenses 1827 ..

1st January 1846

Cawnpore Terminal Line

Fourth and 5th Divisions after [illegible] under the [illegible] of the [illegible]

No	Description	Rate	Amount	Total
1	Ex. Engineer		600 ..	
2	Dy. Engineer	200	400 ..	
1	Do.		100 ..	
2	[illegible] Engineers	100	200 ..	
5	Asst. Overseers	65	325 ..	
1	Accountant		60 ..	
1	Clerk		12 ..	
1	do.		25 ..	
1	do.		20 ..	1552 ..
2	[illegible]	20	40 ..	
2	do.	15	30 ..	
1	[illegible]		15	
1	[illegible]		12	
5	[illegible]	6	30 ..	
1	[illegible]		12	
1	[illegible]		8 ..	
2	[illegible]	6	12 ..	
20	[illegible]	4	80 ..	
1	[illegible]		6 ..	
2	do.	4	8 ..	270 ..
1	[illegible]		16 ..	
1	[illegible]		15 ..	
1	do.		8 ..	39 ..
7	[illegible]	10	70 ..	
2	do.	5	10 ..	
13	[illegible]	5	65 ..	
2	do.	4½	9 ..	
4	do.	4	16 ..	
6	[illegible]	5	30 ..	
27	[illegible]	4	108 ..	309 ..

Total Company's Expenses 2163 ..

Cawnpore Terminal Line — Fifth Division

[illegible]

Nil

Agra Terminal Line — Fifth Division

No	Description	Rate	Amount	Total
1	Ex. Engineer		600 ..	
3	Dy. Engineers	200	600 ..	
2	Asst. Overseers	65	130 ..	
1	Accountant		80 ..	
1	Clerk		40 ..	
1	do.		25 ..	1545 ..
1	[illegible]		30 ..	
1	do.		15 ..	
2	[illegible]	20	40 ..	
1	do.		15 ..	
2	[illegible]	15	30 ..	
1	[illegible]		20 ..	
2	[illegible]	8	16 ..	
5	[illegible]	6	30 ..	
3	do.	5	15 ..	
26	[illegible]	4	104 ..	
6	[illegible]	10	60 ..	
1	[illegible]		6 ..	
13	do.	5	65 ..	
4	[illegible]	4	16 ..	312 ..
1	[illegible]		15 ..	
1	[illegible]		12 ..	27 ..

Total Company's Expenses 1884 ..

Total [illegible] Expenses .. ..

Mber

The Establishment shown in the above Table for the 5th and 6th Divisions on the 1st of January 1854, is that which was found to be sufficient after the Amalgamation of these Divisions and when the whole line constituting the Cawnpore Terminal had been placed in charge of Lieut. Hodgson of the Engineers. An inspection of the Table will shew that the reduction chiefly consisted in Office Establishment.

It will be understood that the Establishments above referred to, were dependant-ly on the progress and completion of the works, as well as on the amount of work in hand, and that when this work was completed, and the Canal Channel had received water, an entire revision not only of the Establishments themselves, but of the Divisions or Districts connected with Irrigation, would necessarily follow.

In arranging for the extent of Divisions over which Executive Officers had control during the progress of works, attention was directed to the magnitude and extent of these works, to keeping the duties of each Executive as compact as possible, and to other circumstances of a local nature which at the time presented themselves. On the introduction of water however and the commencement of its dis-

tribution

-tributing amongst the Irri-
-gators, there were other points
to be attended to. It was
considered advisable so to
regulate the lengths of the
Districts, that each Executive
should possess the power of
regulating his supply of water,
and of holding in his own
hands, the means of obtaining
relief to a certain extent from
floods arising from excess of
water in the Canal either from
rain, or from diminution of
Irrigation in parts of the
Canal above his District.

To effect this purpose
it was determined that a
leading feature in the ~~distrib~~
arrangements should be the
possession of an Escape at
the Head of each District,
and that a line of Electric
Telegraph should as early
as possible be carried from
the Nanoon fork, situated at
the heads of the Cawnpoor
and Etawah Terminal lines,
along the Canal bank to
Roorkee and the Myapoor
Regulator. By these means
it was supposed that each
District would in itself have
the power of obtaining relief
by the Escape at the Head
and along the course of its
own Channel, whilst the
Electric Telegraph would enable
the Officer to correspond with
the Districts lying above him
and with the Dams and Escapes
in the northern regions. Ul-
-timately, wires connected with
the Electric Telegraph reading

of place.

Wires might be carried along each of the Terminal lines by which means the whole of the works from the Head to the Termini would be in correspondence. — This design if worked out in extenso would undoubtedly place the whole machine in a very efficient state; it appears to me however to be indispensable as far as the Telegraph between Nunnoon and the Myapoor Head is concerned; as by no Establishment that we could devise, would it be possible to protect our dams against the inconvenience of high floods with such certainty or with such immediate effect, as we could by a well regulated Telegraph.

The proposed limits of the different Divisional Districts for the Ganges Canal when the water has been fairly admitted and the Rajbuhas sufficiently advanced to enable the Cultivators to commence Irrigation may be thus given as a Sketch of what I would recommend in the early State of progress.

The 1st or the Northern Division

The District attached to this Division will extend from the Ganges River at the point where the Canal leaves it to the Futtigurh Branch Head. — Its total length is 50 miles, and it will independently of the Executive Charge of the works embrace the control of the whole of the Irrigation of the

Rajbuhas

Rhadu, as well as that connected
with the Rajbuha Heads at
the Assoffnuggur, Muhmoodpur,
Belra, and Jaoli Falls. This
District will be under the
charge of an Executive Officer
who under the title of "Super-
"intendent of the Northern +
"District" will act in the
same capacity as the Superin-
-tendent of the Eastern or Western
Jumna Canals. He will have
under his charge the whole of
the works, and the control of
the Canal Revenue within
his boundaries. His duties
in fact will correspond with
those of the Officers above men-
-tioned, being responsible both
for the permanent works of the
Canal itself, for the efficiency
of the Rajbuhas, and for the
proper supervision of the water
rent. He will annually submit
to the Superintendent of Canals
N.W.P. the same papers in
abstract of the Expenditure
and receipts with a Balance
Sheet of Gross and Nett returns
with reference to Dead Stock
and dues to Government.

The Head Quarters of the
Superintendent will be at
Roorkee, and he will have
attached to him two Deputies
one of whom will be specifically
placed on the tract North of
Roorkee, the other on the works
and Irrigation on the high +
land stretching from Roorkee
to the Futtiguph Branch Head.
The duties of these 2 Deputies
will possess sufficient variety
to

to enable the Superintendent to form his own selection, founded on the qualifications of the Officer. The leading or 1st Subdivision being that which is confined to the Khadir will comparatively speaking be more connected with works than Irrigation whereas that lying below Roorkee, will have more of the latter than the former. The duties of both Subdivisions however are sufficiently mixed up with Irrigation to qualify an Officer for Canal Revenue duties, a point that I consider to be of great importance in a Department, where the removal of Officers from one post to another is of constant occurrence, and when a knowledge of Revenue matters as regards Canal Irrigation is as indispensable as acquirements in Civil Engineering.

Mr Fannon

In addition to the Superintendent and his 2 Deputies, Mr Fannon who during the progress of the works has conducted the material Department will retain his situation, with the additional duties of superintending the navigation in the Khadir. The object of these double duties is as regards materials to maintain at the different works a large supply of bricks in store which can be done gradually by keeping the village Pazawas or Native Brickkilns in constant progress until a sufficient quantity of material

has been collected; and with reference to Navigation, to Superintend the Lockage and the boating between the Head and the Solani Aqueduct during the early periods after the Water is admitted into the Canal, and when active measures will be required to transport boulders or River Stone for the purpose of laying down the flooring of the Eastern portion of the Solani Aqueduct. It will be understood from what has been said in Chapter IX, that the carriage of boulders to the above point previously to the admission of water was considered to be so far premature, that vast expense would be saved, by its postponement until the line was open for boats, by means of which, moreover, a larger and better sort of boulder would be procured from the main Ganges and its branches, than would be forthcoming from the Mountain passes of the Sewaliks. The early Completion of these boulder floorings, farther, is indispensable for the satisfactory protection of the Eastern front of the Aqueduct from the wear and tear of the Current; and the deputation of Mr. Finn to the special charge of this duty, appeared to me not only to be likely to accelerate progress, but the employment itself was in a great measure allied to that, in which he has given so much satisfaction previously.

The ~~first~~ step means of placing the navigation under the especial management of an Officer was a guarantee ~~it~~ for its proceeding on a proper footing and ~~to~~ the best means I can think of for establishing in the minds of the native community the advantages that were open to the trader from making use of the water ~~as a means~~ of transport. — I believe that a few years of steady progress in the use of the navigable Canal and its lockages on the line between Hurdwar and Roorkee, would be in all probability the certain way of ensuring the ready adoption of the Canal as a navigable line elsewhere.

Including Mr Finn's and his Establishment in that of the Northern District charge, the following is the design of the permanent Establishment that might be considered appropriate.

Northern District

1 Superintendent
2 Deputy Superintendents.

Depy. Superintendent 1st Sub Division	Head Quarters at Roorkee, but liable to be detached to Hurdwar or any point between that and Roorkee. —

Works

4 Overseers — of whom

1 at Myapoor. with a party of
4 Tindals
40 Beldars

In charge of Bunds and Regulation of the Canal banks from the main ranges to the Jowallapoor

Bridge

Bridge.

1 at the **Puttri** with a party of

4 Tindals
40 Beldars

in charge of the Works and Embankments lying between the Jowalapoor Bridge and the upstream extremity of the Dhunowri Revetments.

1 at **Dhunowri** with a party of

4 Tindals
40 Beldars

In charge of the Dam and Regulator and of the Canal works and Embankments from the upstream extremity of the Dhunowri Revetments, to the upstream extremity of the Solani Aqueduct.

1 at **Roorkee** with

8 Tindals
80 Beldars

In charge of the Aqueduct and Embankments, with further charge of "Plant" attached to the works, including Boats, Houses, wagons, railway [illegible]. This person would also be employed in the Estate of Roorkee on the Public buildings and in the [illegible] Department.

Deputy Superintendent 2nd Division | Head Quarter at Roorkee, but liable to be detached to any convenient post between Roorkee and the Futtighur Branch Head.—

Works.—

1 Overseer, who would be detached to either Belra or Jaoli, so as to be in the vicinity of the works at the Southern extremity of the District with

1 Tindal
10 Beldars

over each of the falls viz. those at

Asufnuggur
Mohummudpoor
Belra
Jaoli.

[illegible] of

4 Tindals and
40 Beldars

96

I may observe with reference to these permanent Below Establishments that I would consider them as entirely probationary. On the Khadir and North of Roorkee where the population is small, and where the Regulating arrangements at Myapoor and Dhunowri render the presence of a skilled Establishment indispensable, these Establishments may possibly be of the utmost importance to the defence of the works. South of Roorkee, however, the necessity of maintaining large and expensive bodies of men may be questionable. In the early periods of the flowing of the water they may be useful and under the [illegible] that they may be recommended subject to after revisions, dependent on the experience gained by dealing with the running water.

Executive Officer of Materials and Superintendent of Navigation

Retaining, with a party sufficient for working the Locks and maintaining the Navigable Canal in an efficient state for the passage of the Craft, the Timber Office and other Establishment I would leave as it is at present, reducing it as opportunity offered and as a necessity for so doing arose from actual experience.

I would say the same of the Office and Establishment of the Superintendent or Executive Officer, a number of Chuprassies

crassies and subordinate people would necessarily be discharged on the completion of the works. There could not possibly be any use for so great a number as they are at present. The Office which now exists was raised for a specific purpose at a period when the Accounts and responsibilities of the Executive Officers were enormous; this part of the Establishment &c would place on the same footing as it was originally as shewn in the list for January 1848; that list in fact would be the scale upon which the whole permanent Establishment of the Division might be reorganized.

The Revenue Establishment must necessarily be regulated by the new code upon which Capt. Baird Smith is now engaged, the details of which will greatly modify the existing scale as practised on the Jumna Canals. In the meantime, however, I should consider that a Zilladar and Naib Zilladar for each 50 miles, and a Daroga for every 10[illegible] miles in length of Canal Irrigation would be sufficient, the Establishment for collecting being regulated by that now existing elsewhere, with Chowkidars at each of the Chokee posts. –

Under the above plan therefore, the Scale for the Executive Establishment would be as follows

1. Superintendent of the District
2. Deputies
6 Overseers
1. Executive Officer of materials and Superintendent of Navigation

in the present [illegible]

Wakefford

The 2nd Division

The District attached to this Division would extend from the Futtiguni Branch head on the main line to the head of the navigable cut at the Bhola Falls situated immediately above the Dakhnoo Khoord Escape. It would not include any of the Bhola masonry works ~~[illegible]~~ with its limits. The whole of the Futtiguni Branch would be included in the 2nd Division, which would therefore consist of 33 miles of main canal, in addition to the Futtiguni Branch. The means of regulating the supply in this Division as far as rests with itself, depend on the Futtiguni Branch which lies at its immediate head, and on the Khutowli and Aboos nulla Escape, which are situated at the 62nd and 69th miles. The close proximity to the northern Division, however, gives this district great advantages in correspondence with the Dams in the Khadir, the lowest of which, vizt. that at the Kutnoor is situated 36 miles north of the Futtiguni Regulator.

At the time that I am writing the Futtiguni Branch has not been excavated, and its completion would define the future scale of Establishment for the Division. In the mean time, however, I would lay down

the same rules here as I have
done for the Northern District -
ought to adopt the scale of 1862
revising it to any extent that
may appear applicable to the
particular circumstances of
the case - and with regard to
revenue Establishment confine
it within the limit which
practical experience has shown
to be sufficient on the Jumna
Canals. The supervising Es-
tablishment ought to be regu-
lated as follows.

1 Superintendent of the District
3 Deputies.
11 Overseers.

The district to be divided into
3 Sub Divisions as follows.

1st Deputy in charge of the
main line of the Canal
from the Regulating head
to the Navigable head
and Rajbaha of the
Bhola Falls with One
Overseer attached.

The 2nd Deputy would have charge
of the Regulating heads at Pail
with a working establishment
on the following scale for the
duties.

4 ~~[illegible]~~ Tindals
40 Beldars

For the Falls and Locks at Chitaura
and [illegible], there would be
the working Establishment
consisting of

1 Tindal
10 Beldars

for each work.

For the Escapes at Khatauli
and [illegible] nullah, there would
be

use in an Establishment of
1 Sindhi
4 Beldars
at each lock.

These parties would be considered available for clearance, removing [illegible] [illegible] and [illegible] [illegible] [illegible], and [illegible] [illegible] in [illegible] the boundaries [illegible] within which each party was located, in perfect order and [illegible] [illegible] [illegible] [illegible] [illegible] upon.

It will be seen that for the working and maintenance of the Regulators, Falls and [illegible] the above [illegible] permanent [illegible] [illegible] and [illegible] 6 [illegible] [illegible] [illegible] sufficient to do much useful work in the [illegible] [illegible] [illegible] [illegible] upon.

[illegible], however, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] parties of Beldars, [illegible] [illegible] [illegible] [illegible] required [illegible] [illegible] [illegible] [illegible] the regulation of water, [illegible] it may be questionable [illegible] [illegible] [illegible] [illegible] [illegible] at [illegible] danger [illegible] [illegible] [illegible] experience has [illegible] that [illegible] in this description [illegible] [illegible] by the [illegible], do not work [illegible] [illegible] [illegible] [illegible] equal to the [illegible] [illegible]. [illegible] parties, [illegible] [illegible] the immediate attendance [illegible] of [illegible] [illegible], and [illegible] the [illegible] [illegible] after

the admission of water, this may be a consideration in their favor.

The Futtehgurh Branch would on its completion require the attention of 2 Deputies and 3 Overseers, with working Establishments on the same scale for the Falls and Locks, Escapes, &c. as I have proposed for the Main Canal; by the time however, that this work is completed and supplied with water, sufficient experience will have been gained to render the scale of Establishment required for its maintenance quite clear, without any speculative opinions being advanced at the present time.

The 2nd Division

The District attached to this Division would extend from the head of the navigable Cut at the Belra Falls to the Kasimpoor Escape and Bridge, or from the 83rd to the 166th mile. It would include within its jurisdiction the Boolundshuhur and Koel Branches to their junction near the Town of Hattrass, and it would terminate at the [illegible] end of the Kasimpoor Escape, with which work its Superintendant would, however, have no concern.

This District therefore consists of 83 miles of the main Canal; 90 miles of the Boolundshuhur and 56 miles of the Koel Branch.

At the present time

retain

neither the Blind drainage nor the Rod Branch have been excavated. The working out of any organized system of establishment would depend therefore on the completion of these works.

Graham

The Superintendent [illegible] responsible [illegible] at the head of the Division & frames the orders for Regulating [illegible] supply in the [illegible] [illegible]. Besides the Leading Branch, the Blind drainage and Rod Branch [illegible] [illegible] particular [illegible] the control and management of the water, and the [illegible] [illegible] [illegible] at the 3rd [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the 2nd District appears to [illegible] to be well adapted to the [illegible] [illegible] under which it is placed.

The [illegible] Division [illegible] would be

1 Superintendent [illegible]
1 Deputy
4 [illegible]

[illegible] District would be divided into subdivisions each as [illegible] under a Deputy Superintendent.

The [illegible] Division [illegible] [illegible] [illegible] navigable [illegible] at the [illegible] Falls [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Canal with the charge of the works [illegible]

Branch.

This Deputy would have charge of the Falls at Bhola and Dasna, as well as the management of the Boland Escape regulator; he would have 2 Overseers under him, one ~~specially~~ special in charge of the Sanni Khurd Escape and the Bhola Falls. For the former I would give the same working establishment as ... 1 Tindal and 11 Beldars for each of the Falls, 1 Tindal and 4 Beldars for the Sanni Khurd Escape, and for the Regulator I would give 4 Tindals and 40 Beldars.

The 4th Subdivision would extend from the Moradnagar Escape downwards (including these works) ~~[illegible]~~ to the tail of the Districts or to the upper end of the Assiyur Escape. ~~with~~ The Mat Branch would also be included in this Subdivision.

This Deputy would have charge of the Moradnagar Escape, of the Falls at Pilkhua and Simra, and of the Regulators at the head of the Mat Branch, with 2 Overseers under him.

The working parties at the above works would be as follows:-

Moradnagar Escape.	1 Tindal 4 Beldars
Falls at Pilkha.	1 Tindal 10 Beldars
Do at Simra	1 Tindal 10 Beldars
Mat Regulators	3 Tindals, 30 Beldars

I would make the conditions on which the maintenance of this permanent

establishment

Establishment rates similar to those above described; the Establishment of [illegible] and Beldars as per [illegible] Establishment would in fact be [illegible].

The Superintendent's Office and Divisional Establishment would be determined on the scale of that recently approved by Government; and that the annual [illegible] would be framed on the basis of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Establishment [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] District [illegible]

[illegible] District would include that part of the main canal extending [illegible] [illegible] from [illegible] to [illegible], or from the 100th to the 150th mile in addition to the Terminal lines running towards [illegible] and [illegible].

The division from [illegible] comprises the leading regulator [illegible] [illegible] [illegible] [illegible] the [illegible] of the Terminal lines, and the Regulating bridges at the heads of the Terminal lines acting [illegible] [illegible] [illegible].

The Engineering Establishment would consist of

1416

To Superintendent of the Canal [illegible]
1st Deputies
Divisions —

As this District is of a much greater extent than the others, especially in its connection with the Hatras Irrigation, I propose assigning two Deputies under the heads [illegible] the 1st class on a higher salary of 300 Rupees, and the remaining two second class on the usual salary of 200 Rupees per month.

The 1st Class Deputy should have the immediate charge of the main line from [illegible], and the [illegible] Regulator, with the intermediate line channel and its Irrigation, and the [illegible] [illegible] Station.

The 2nd Class Deputies having both [illegible] divisions as follows:

1st Sub Division — From the [illegible] Regulator along both of the parallel lines of channel extending to the Bridges on the high road between [illegible] and Etawah.

2nd Sub Division — From the Bridge on the [illegible] and Etawah Road on the Cawnpore Terminal line to the end at Cawnpore.

3rd Sub Division — From the Bridge on the [illegible] and Etawah Road on the Etawah Terminal line to the Jumna —

[illegible] 1st Class Deputy [illegible]

of the [illegible] Regulators would
[illegible] [illegible] the following
[illegible] [illegible] [illegible]
[illegible]

[illegible] Gauge — [illegible]
[illegible] [illegible] Regulators 2 [illegible]
20 [illegible]

Remarks

The 1st Class Deputy [illegible]
would [illegible] [illegible] Speaking
[illegible] a [illegible] division of Small
[illegible] but [illegible] would [illegible] avail
[illegible] [illegible] [illegible] [illegible] duties
[illegible] the regulation of the [illegible]
[illegible].

I would [illegible] [illegible]
[illegible] the Establishment
[illegible] 1st and 2nd versions
[illegible] [illegible] [illegible] this, [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
out in the [illegible].

[illegible] [illegible] [illegible] and
[illegible] [illegible] [illegible]
[illegible] that [illegible] [illegible]
[illegible] new [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
brought [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] Regulators,
[illegible] [illegible] the [illegible]
[illegible] [illegible] the [illegible] Canals
[illegible] and [illegible]
Establishments, and which I
would recommend as a [illegible]
[illegible] [illegible], would be
superseded [illegible]
[illegible] [illegible] [illegible] [illegible] to
[illegible] [illegible] the precise [illegible]
[illegible] of Subordinates that
may be required [illegible]
[illegible] [illegible] [illegible]

in force in 1845 both as regards Office and Working Establishment, a reasonable scale upon which we can base any after modifications appears to be provided.

Looking therefore to the statement for 1845 given in the early part of this Report as that which provides a scale for both the Office and Working Establishment of each of the proposed Districts, & merely in recapitulating the European Establishment required for each, and the length of Canal in miles which each Superintendent has to control, give a distinct idea of the distribution of the Executive, which I think would commence with the Superintendent Central, would supervise the works and regulate the Navigation of the Ganges Canal. ^*

Superintendent Central

1st or Northern District

1. Superintendent	1st Sub Divn: 1 Deputy Superintendent and 2 Overseers, above Roorkee, distance 19 miles	From the Canal Head to the Futtehgurh Branch Head 50 miles
	2nd Sub Divn: 1 Deputy Superintendent and 1 Overseer, below Roorkee, distance 31 miles	

1 Executive Officer of [illegible] Supt & Navigation from Canal Head to Roorkee.

2nd or [illegible] (Upper Central) District

1. Superintendent	1st Sub Division: 1 Deputy Superintendent and 1 Overseer in charge of Regulating Heads, Main line of Canal to the [illegible] Head at the Bhola Falls 35 miles	Total Length of District
		Main 35
	2nd Sub Divn: The Futtehgurh Branch in which 2 Deputies and 3 Overseers would be employed. 165 miles	Branch 145
		Total 1[illegible]8

^* I may however remark that altho' in the preceding details, as well as in the following summary I have fixed the scale of number and grades of Depty Supdts at the lowest possible point; I am of opinion that it would add to the efficiency of the [illegible] if it were to be understood that in cases of high merit each Distr might have one 1st Class Deputy, not of necessity, but as a stimulus to exertion, or reward for good work done.

3rd or Bolundshuhur (Lower Central) District

1 Superintendent

- **1st Sub Div.** 1 Depy. Superintt. with 2 Overseers. From the Bhola Falls to the up stream end of the Mirunda Khera Escape with charge of the Bolundshuhur Branch ... 150 miles
- **2nd Sub Div.** 1 Depy. Superintent with 2 Overseers. From the upstream end of the Mirunda Khera Escape, to the upstream end of the Kasimpur Escape, with the control of the Koel Branch and its regulation. Distance 73 miles.

Length of District

Mainline	83
Bolundshuhur Branch	90
Koel do	50
Total	223

4th or [illegible] District

1 Superintendent

- **1st Sub Div.** 1. 1st Class Deputy Superintt. with [illegible] Overseers from the upstream end of the Kasimpur Escape to the [illegible] including the regulation at that point 114 Miles
- **2nd Sub Div.** 1. 2nd Class Deputy Superintt. with 2 Overseers from the [illegible] Regulator to the Mynpoorie [illegible] on [illegible] Terminal line. Distance 70 [illegible] miles
- **3rd Sub Div.** 1. 2nd Class Deputy Superintt. with 2 Overseers from the [illegible] to the Mynpoorie [illegible] Road on the [illegible] Terminal line with [illegible] miles
- **4th Sub Div.** 1. 2nd Class Deputy Superintt. with 2 Overseers from the Bridge on the Mynpoorie and [illegible] Road on the [illegible] Terminal line to the [illegible] 105 miles

Total Length of District

Mainline	114
[illegible] Terminal	170
[illegible] do	175
Total	359

The total number, therefore, of European Officers required on the Canal as laid down independently of the Superintendent General, would be.

4 Superintendents of Districts
11 Deputy Do {1. 1st Class; 10. 2nd do}
1 Dy. Officer of Materials and Superintendent of Navigation
16 Officers —

With reference to the last item I would by no means confine the [illegible] to [illegible], the situation [illegible] to Europeans. Europeans [illegible]

and chosen for their qualifications
in being quick at resources, or in-
terested in the peculiar duties
on which as Canal Overseers they
will be specially placed, are
undoubtedly to be preferred; if,
on the contrary, they are unselected
and placed upon the works as
they have been during many a
life [illegible] merely because
they had passed a fair examina-
tion at the Roorkee College, I would
rather have natives. Eu-
ropeans in fact, unless they
have qualifications which enable
them to submit to the solitude
of [the] remote District posts without
repining, unless they are gifted
with steadiness of character, and
quickness at resources, and
in anticipating accidents, are
in many cases worse than useless.
Unsteadiness of character whether
arising from intemperance or
neglect of duty is absolutely ru-
inous to any works with an
active agent like that with which
we have to deal, constantly op-
posed to us. Running water
won't wait upon the convenience
of either Sergeant or Corporal,
and a man who won't or can't
mount his horse at any period
of the night or day, to visit the
extreme limits of his Division
is utterly unfit for Canal Service.
If Europeans are appointed to
this duty, they ought to have
horse allowance. I would give
each man 20 Rupees a Month
as sufficient for the keep of 2
horses, and I would place such
power in the hands of the Super-
[illegible]

N. W. 609, 1st [illegible]

=intendent General, that neither should this allowance be made applies, nor should any European have the power of retaining his place one moment after he had either by drunkenness or neglect forfeited his claim to the Confidence of the Superintendent of the District. On the other hand the Superintendent General ought to have the power of rewarding good conduct and of promoting to a higher grade in the Department those men who signalize themselves by meritorious conduct; to effect this the Establishment of Overseers might be divided into three grades, each step giving an increase of salary. With regard to a choice between the European and Native in the situation of Overseer, my opinion after now nearly 30 years of experience is, that a good European is invaluable, a bad one is not only worth nothing, but he is so expensive and troublesome that his presence on the works is injurious to their interests, and in many cases he becomes absolutely dangerous, from the natural tendency that exists to entrust him with orders, and to place confidence in his energy of character.

The Native wants the energy of the European, and generally speaking does not carry with him weight suf-

-ficient, to control his subordinates but in other respects, he has attributes of a very high order, temperance, sobriety, knowledge of the people over whom he is placed and very great intelligence. During my career I have certainly had less disappointment with natives than I have had with Europeans, a result which is probably arrived at, from the former being more under control, and as such being more subject to summary punishment, than the latter. The European when once appointed to the Department can only be punished by suspension, subject to the orders of the Board, whose position in Calcutta at a distance of a thousand miles, renders immediate retribution impossible. Removal from the Department can only be effected by a reference by the Military Board to the head of the Supreme Government, so that what with one delay and another, I have known a man to remain under suspension for nine months, drawing full canal salary before any orders were given as to his ultimate disposal. This acts both ways, the Canal Officer is restrained from bringing to the notice of his superiors acts which will lose him the services of the only man probably to whom he has to look for carrying on business, with little chance of a speedy settlement of the

question

Question at issue; the European Overseer takes his measures accordingly, and if a bad man, is indifferent to results so fearfully procrastinated. This appears to me to require remedy.

Improvement

In the Canal Department an Assistant Overseer when appointed either from the Civil Engineers College at Rooke, or direct from his Regiment, joins the Superintendent of a Canal and is at once sent on detached duty. There at a distance from Society, with a control over native subordinates, and with a management of works, that ought properly to be entrusted to an experienced man only, the young Overseer has to learn his duty as well as he can. He is selected from the Rooke College without the slightest reference to his turn for building or Civil Engineering; his study at the College is of books only, and he reaches the Department in which as I have shewn he is immediately called upon to take up duties requiring knowledge and experience, as ignorant and as inexperienced as he could well be. Under such circumstances can it be wondered at that a young raw Barrack recruit goes wrong? The consequences are fatal to the unfortunate man in numbers of instances, the Government works suffer by all sorts of mistakes and blunders, and the Executive Engineer who is held responsible for the cost and quality of work.

done has literally nothing to do, but to look on and bear it. The remedy that I would propose is this that men when they have passed their examination at the College, should be drafted off in parties of from 2 to 10 in number, and sent to the Head Quarters of any Department or Division of public works, which was most extensively employed in building. The men should remain on probation actively employed on these works under the eye of the Executive Engineer or his Assistants, and at the termination of 2 years, his retention in the Department of Public works at all should depend upon his efficiency as a builder, or as an Overseer over buildings, the determination on these points being guided by the report of the Executive Engineer under whom he has been probationarily employed. No Assistant Overseer ought to be sent on detached duty until he has passed through 2 years of probation in actual building under the eye of an Officer. —

The education of the European Overseer at the present time, is confined to 6 or 12 months reading at the Roorkee College. It is entirely theoretical. Previously to admission he is called upon to pass an examination on the following subjects;

Reading
Writing

Arithmetic

Arithmetic as far as vulgar fractions
Elementary Geometry
Mensuration
Simple plan Drawing. -

He is passed out of the College by a process equally easy. - He then commences a series of which I have attempted to give an explanation above; now why should not the period be extended to a similar course of practical building at Roorkee, to an acquisition of knowledge on the different details of brick and mortar practice, as called for in the Department of Public Works; to becoming acquainted with the native terms and expressions used in the profession that he is about to embrace, to a comprehension of the cost and value of work of different descriptions, and to the general details of matters that [illegible] will necessarily come before him? The 2nd Class of the College which consists entirely of Non Commissioned Officers and Men who are intended for the Department of public works might it appears to me have its standard of proficiency raised very greatly by some such modification of the present system. - That this will be done eventually, or in its absence that the 2 years of Probationary service should be called for from each Assistant Overseer I hope for with all my heart not merely for the good of the service alone, but in justice

to the Young European, who in the present state of things is not fairly dealt with. —

When an European enters the Department without the ordeal of entering the Roorkee College, his Qualifications are judged of by an Examination carried on by a Committee of Engineer Officers, the extent of which is a knowledge of Arithmetic, Mensuration, and an Estimate of the Cubic Content and Cost of a plain barrack building. — In this case the man on his entering the Department of Public Works is worse off than his Contemporary from the Roorkee College; the last is educated and prepared in a small degree, the former in nine cases out of ten has no education at all. —

Believing that the deficiencies noted above are as prevalent to the Public Works in general as they are to the Canal Department. In the latter, however, the posts of Overseers are with one solitary exception, viz^t. at Roorkee, detached from the eye of Officers, and ought not to be trifled with. The men selected for these duties might with the greatest advantage to the State be not only better educated, but be selected for their inclinations leading them to Civil Engineering as a pursuit, and not as a mere change from the

routine

(Lawson

routine of Regimental duty—

Since the Establishment of the Civil Engineer's College at Roorkee, and its division into 3 Classes; the 1st being for the more highly educated, and those capable of being employed on the duties of Sub Assistant Civil Engineers, the experiment has been tried of drafting Students of this Class into the Canal Department. Four of these young men were placed under the orders of Executive Engineers, and with the exception of one who was removed for indolence and misconduct, they have got on very well; their duties have been confined to road surveying and levels, to measure, and have to survey, lay out, and excavate Canal Channels, form embankments, and plant trees; they have also had to superintend Masonry works, such as Bridges, Drain heads, Outlets, &c. &c. All these they have to draw out their own plans copied from the Office designs, to return measurements of cubic contents of work, and to submit monthly accounts to the Executive Engineer. [illegible] 2 men of this description on the Cawnpoor Terminal line, who have at the present time served 5 years; as far as I can gather from the reports of the Officers under whom they serve, and from my Annual Inspections, the work done by these men is equal to that performed under European Superintendence, and as far as building and the correct

finishing of buildings is concerned, better. The only want that this class of people has, is the active energy which the European naturally possesses. Madho Ram and Pitumber Sing, the gentlemen to whom I allude above, have shown themselves highly deserving of the confidence of the Executive Engineer, and are good specimens of material which may ultimately be turned to excellent account in the Department. The rate of pay of the Sub Assistant Civil Engineer is 100 Rupees per month, with allowances when marching equal to 3/10th of that salary.

The 1st Class which produces the Sub Assistant Civil Engineer is followed by the 2nd Class, which is especially devoted to Non Commissioned Officers and Privates for education as Overseers, in this Class there is an Uncovenanted Department which is also intended to supply the Public works with Overseers and Supervisors. I have before remarked that great benefit would be derived from these men being made to undergo a series of practical studies on construction before they were allowed to be detached; that this should be done appears to me to be indispensable. Men of this Class, moreover, should not leave the College until they had acquired a knowledge of the technicalities of the profession on which they are about to enter, they ought not only to speak

the

the language freely, but to speak that language which would enable them to hold a conversation with the native mason, smith and carpenter; they ought at any rate to know the native name for a 'Brick' or for a 'Brick mould'; information which many of the men now received in the Department of Public Works are altogether ignorant of. — Non Commissioned Officers and Privates on their reaching Roorkee ought not to forget that they are soldiers, and this ought to be instilled into their minds during their education at the College; examples of an utter forgetfulness of military discipline [illegible] military discipline [illegible] a subject by no means uncommon and rough reminders are every now and then required, as it is unadvisable to be [illegible] as to the [illegible], to bring to the soldiers mind that discipline is not [illegible] in the absence of the Sergeant Major. —

The 3rd Class at the Roorkee College is especially for the education of native surveyors, draughtsmen, &c; it is in my opinion the most useful division of the College — From hence are derived the numerous native levellers, surveyors, and draughtsmen, who are holding posts under the Road Committees, Surveys, Canals &c. a hiatus has been

[illegible]

filled up by the introduction of this class, which has long been the drag upon all progress; European agency was too costly, exposure to the Sun and climate was a bar to the indiscriminate employment of the European on many out of door duties, [which] are now readily filled up by the natives; and as draughtsmen, the wonderful perseverance and delicacy of manipulation for which the Native is incomparably superior to the Common run of Europeans, render him invaluable either in Mapping ~~and~~ or Plan drawing, whilst the comparatively low rate at which the native can live in India, and the few wants which his position demands, makes his services available, where the monthly pay of an European would be utterly prohibitory.

Native Draughtsmen in the Director's Office who have certainly had the advantage of the instruction and supervision of Mr. [illegible] the Head Assistant, whose acquirements as a draughtsman himself are of a very high order, do the whole of the work of copying and reducing that exists in that Office. The execution of their work is equal to anything that could be desired, and far superior to that of the Common class of European who is available for this purpose in India. A salary of 200 Rupees a month or £240 a year, was insufficient to secure a man of the latter

stamp

trade, with acquirements of a very ordinary description, whereas the highest salary in the Director's Office to the Native Draughtsman is 50 Rupees a month or £60 a year. Many other maps and plans ~~which~~ ~~are~~ figured in the Atlas which is attached to this volume, are done by either Kader buksh, Wuzeeroodeen, or Luthfoolah Khan, the three leading men in the Office, and for neatness of execution, and [illegible] accuracy of copying (neither one of the three being acquainted with English any further than its written character) they would not fail in comparison with drawings done by European [illegible]

Hull

[illegible] and surveyors [illegible] are attached to the different Executive Offices, and [illegible] draw [illegible] to [illegible] Rupees a month, save a great portion of [illegible] Surveys and cross sections [illegible] made to Road making. they are invaluable in reading obtaining in a small time, a rough configuration of ground previously to the designing of works, and they relieve the European Officers from the expensive and constantly re-curring labor, that previously to their introduction occupied a great portion of his time.

With the Road Com-mittees they are the means by which the alignments of roads are determined, and [illegible]

in addition to the operations of Survey and Mapping, they take an active part in the execution of the works.—

Although the 3rd Class in the Civil Engineers College at Roorkee has now been in existence only for 5 years or thereabouts, it has passed out the following Students, who have received employment as below.

Roads and Public Works	6
Surveys &c	2
Canals & Improvements	23

besides having afforded education to numerous young men who have not been publicly provided for. It has, moreover, introduced an element of competition amongst the Mootsuddi and Lalla Class for which the neighborhood of Roorkee is celebrated, which is likely to be exceedingly beneficial not only in the Department of Public Works, but in all Departments connected with the general improvement of the Country in works of public utility.—

With reference to the subject of this Chapter therefore, it will be seen that the System of education now in force at Roorkee, is likely to be of great aid to the Canal Department in general and to all improvements where Irrigation is concerned; that we may depend hereafter on an Institution from whence we may derive men of 3

Assistants

different classes to aid us in our progress, and that we shall not be, as heretofore, dependent entirely on our own individual exertions for every step of advance that is made towards improvement. —

There are two points which in closing this Chapter, I may very properly draw attention to; the first is the Nomenclature of appointments that now exists in the Canal Department, the 2nd is the position that the Chiefs of Districts are to hold with regard to residence. These are questions which have up to the present time led to much confusion, and from the experience that I have had appear to me to require remedy. I shall, therefore, say a few words on each, taking them in the order of their precedence.

1st The Nomenclature of Appointments.

Up to the period at which I am now writing the Chief authority in the Canal Department is entitled "Superintendent of Canals in the North West Provinces and Director of the Ganges Canal works". The former being generally applicable to his control over the different Canals in the neighborhood, and the latter specifically addressed to the [illegible]

in carrying out the works of the Ganges Canal. –

Under the first head he has under him. –

1st The Superintendent of Canals west of the Jumna

2nd The Superintendent of Canals East of the Jumna

3rd The Superintendent of Canals in the Doon –

4th The general superintendence of the works on the Nudjufgurh Theel the detail of which is specifically under the Civil authorities at Delhi. –

Under the 2nd head he superintends the whole of the Executive Establishment of the works on the Ganges Canal, with the control of accounts [illegible], the appointment being as [illegible] before a specific one, to this there can be no objection it depends upon the progress and carrying out of a very extensive board of works.

The confusion that now exists arises from the term "Superintendent of Canals" being applicable to the chief as well as to the subordinates, they are all Superintendents of Canals, and laying aside the office as applicable to the particular works upon which each Officer is employed, there is no distinguishing mark to separate one from the other. This impression is not confined

to

[illegible]

Note — [illegible]

[illegible]

[illegible] naturally [illegible] intended for the purposes of Brigade, [illegible]

[illegible] Admiral [illegible] [illegible] of the [illegible] made [illegible]

[illegible]

No.	Superintendent	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
		[illegible]
6		[illegible]
		[illegible]
7		[illegible]
		[illegible]
8	[illegible]	[illegible] Island
		[illegible]

[illegible] with [illegible] Island [illegible]

[illegible] [illegible] States [illegible] that [illegible] [illegible] [illegible] This would be a complete [illegible] the conquest of [illegible] and titles that now exist.

1st. [illegible] Buildings
[illegible] Establishment [illegible]
[illegible] Districts

[illegible] [illegible] [illegible] which [illegible] [illegible] District [illegible] [illegible] [illegible] is [illegible] [illegible] [illegible]. It is advocated by [illegible] particularly [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] provided with a permanent [illegible] fixed place of residence [illegible] accommodation [illegible] [illegible] [illegible] [illegible] [illegible] fixed accommodation [illegible] [illegible] purpose; and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] District [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Office, and [illegible] [illegible] [illegible] [illegible] [illegible] Superintendent of the District should [illegible] Head Quarters, and [illegible] ought to [illegible] a [illegible] of the [illegible] [illegible] [illegible] [illegible] Engineer [illegible] [illegible] should reside [illegible] at the Station [illegible] the District Office is fixed, but in the immediate vicinity. As to the accommodation required.

required for the Officer who resides
at a Head Quarter Station of the
unit is not very extensive. I would
perhaps look on as a desideratum in our
Head Quarter residence to have the
[illegible] of the District;
an arrangement which would
determine at the outset the question
[illegible] the [illegible] Canal; at present
the undecided as well as uncertain
one as to where the Head Quarter
Station ought to be fixed. It would
[illegible] the proximity of the
Office to the presiding Officer
and it would place him upon
[illegible] District on a
par with those [illegible]
responsibility of whose situation
[illegible] made it desirable that the
Office [illegible] should [illegible]
[illegible].

The Cost of an Office
building built in brick and
mortar that is to say a per-
manent structure, sufficient
for Office purposes, may be
estimated at 2000 Rupees, or
200 sterling.

The Cost of a residence
for the Officer [illegible] 50
Rupees a month would be de-
ducted for Public residence,
allowing that 10 per cent is
sufficient interest for capital
[illegible] its construction, would
be equal to 6000 Rupees.

Combining the two
buildings under one roof this
would on the above Estimate

be

is an available sum of 5000 rupees to expend on the public accommodation above allowed by additional outlay in offices [illegible] the total outlay up to 10000 Rupees for each office and residence of Superintendent of District. The Superintendent [illegible] would [illegible] rate value of 600 Rupees per annum [illegible] and [illegible] accommodation for the [illegible] [illegible] of records.

Summary

[illegible] which would [illegible] [illegible] public buildings, the total cost [illegible] would be 20,000 Rs.

[illegible] of the buildings [illegible] would [illegible] would be as follows—

1. Superintendent of Northern District	Rs 10000
2. Superintendent of [illegible] and Central [illegible]	Rs 2000
3. Superintendent of [illegible] Central District	[illegible] provided in the [illegible]
4. Superintendent of Western District	[illegible]

[illegible] would [illegible] a security for permanence of [illegible] in the [illegible] of Districts; and it would be economical as well as tending to efficiency, [illegible] the [illegible] carried out in determining fixed posts for [illegible] [illegible] [illegible] [illegible] offices at [illegible] might be [illegible] [illegible]

[illegible] that purpose [illegible] the [illegible] [illegible] the [illegible] paid to the [illegible] [illegible] [illegible] [illegible] [illegible] at [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] determined, but [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] capital [illegible] [illegible] [illegible] House [illegible] [illegible], and that [illegible] monthly deduction [illegible] House rent from a Deputy Superintendent [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] made, the outlay [illegible] each residence [illegible] the former would [illegible] [illegible] [illegible] [illegible] the latter [illegible] [illegible] the total [illegible] required [illegible] [illegible] [illegible]:—

[illegible] [illegible] residences [illegible]

[illegible] [illegible] 3000 [illegible] 33000

20 [illegible] [illegible] residences [illegible]

[illegible] [illegible] 19200

[illegible] [illegible] 52200

[illegible] [illegible] [illegible] [illegible] houses at the Deputies would reside at [illegible] place [illegible] would [illegible] [illegible] [illegible] [illegible] residences;

5 [illegible] 3rd Class Residences;

[illegible] at [illegible],

[illegible] at [illegible],

[illegible] at [illegible],

[illegible] at [illegible],

[illegible] at [illegible],

[illegible] [illegible] [illegible] [illegible] [illegible] would [illegible]

[illegible] [illegible] [illegible] Residences

2. on the Sultan[illegible] Branch
the [illegible] [illegible] would
[illegible] [illegible] [illegible]
the [illegible] [illegible]
§ at [illegible] :

[illegible] 2nd [illegible] [illegible]
§ on the Sultan[illegible] Branch
§ at some intermediate point
where the Sultan[illegible] Head
and the [illegible] Falls,
on the [illegible] [illegible]
Canal.

In the 3rd [illegible] [illegible]
[illegible] [illegible] would be
2. 2nd class [illegible]
§ at the Bolund[illegible] Branch Head
§ at [illegible] Branch Head !

[illegible] 3rd class Residences
§ on the Bolund[illegible] Branch
[illegible] [illegible] [illegible]
§ [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
Head of the Branch at
[illegible] would pro-
bably [illegible] [illegible] [illegible]
§ [illegible] [illegible] [illegible]
[illegible] escape [illegible]
[illegible] would [illegible] [illegible]
[illegible].
§ at some intermediate point
between the Bolund[illegible]
Branch Head and the
[illegible] [illegible] on
the Main Canal.

In the 4th or terminal District
these would be
1. 2nd class Residences
§ at the [illegible] Regulators
§ at some intermediate point
between the [illegible] end
and the [illegible] road [illegible]
[illegible] [illegible] [illegible]
[illegible]

Canal. —

1 at some intermediate point between the [illegible] and Canal Road and the [illegible] Terminus.

1 at some intermediate point between the [illegible] and Canal Road and the Canal Terminus on the Domain!

7 Cruisers. 3rd Class Residences

1 at the [illegible] [illegible] Prospective [illegible] which would have [illegible] [illegible].

1 at } [illegible]

1 at }

1 at } The position of these

1 at } [illegible] of this Town

1 at } would be [illegible] and

1 at } [illegible].

[illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] in [illegible] plan it would prevent his residence [illegible] to the [illegible] [illegible] and [illegible] [illegible]; and [illegible] the [illegible] it would [illegible] the [illegible] [illegible] [illegible] [illegible] to a [illegible] extent on the Domain [illegible], and [illegible] [illegible] [illegible] to Cruisers, and [illegible] the objects of this [illegible], viz: the building of private residences at detached and favorite spots, and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible], or [illegible] [illegible] [illegible] locality I [illegible] that by providing the

the whole of the Es-
-tablishment with private
residence (for which it must
be recollected the State would
receive an interest in house
rent) the Canal Department
would be relieved from one
of its greatest interruptions and
the want of permanence in
the disposition of its European
Subordinates. –

[illegible]

Section II. Ordinary Repairs

I have in the 1st Section of this Chapter endeavoured to give an outline of the Establishment (Personnel) that may be required for the maintenance, with works and supervision, of the Irrigation; I will now enter upon the Ordinary Repairs & the probable Annual Cost that will be entailed upon the Government for keeping these works in efficient repair.

In estimating this amount, we must take into consideration the large masses of water with which we shall be called upon to deal, the great extent of building that exists in the Khadir tract above Roorkee and the [illegible] of the Ganges Canal, the different small works for Irrigation in these Provinces. The Western Jumna Canals the difficulties of which as regards

Tempo...

shed are overcome by a circuitous course running along the natural beds of Rivers, offers no analogy to that of the present work, We naturally therefore, look to the Eastern Jumna Canal, where the numerous Dams opposed to mountain torrents, and the multitudes of masonry Falls or descents to overcome the natural slope of the country, present although in a comparatively small degree, features by which we may be guided in arriving at an Estimate of the annual expenditure required on the proposed works.

There are two ways of arriving at a comparison; the one by placing the total Annual expenditure in a ratio to linear dimensions; the other, by bringing the same outlay to bear on the average discharge per second in cubic feet.

With the above in view, I shall take the average cost on the last 6 years incurred in maintaining the Eastern Jumna Canal, as during this period, there has been a good deal of repair to the Dams and Channels in the immediate neighbourhood of the Head, and the cost offers perhaps a fair comparison than two other like periods of the same length, when the headworks had had

little

Addl. — The expenditure [illegible] as appears from the year 1882/83 to the year 1892/93 the mean cost of annual repairs on the Eastern Jumna Canal has been as follows.

[illegible] repairs [illegible]	37586	12	11
Current repairs	35416	8	7
Total mean expenditure	72002	3	6

The total length of channels [illegible] is 137.2.186 or say 137 miles. The mean discharge per second may be estimated during the period above referred to at 800 cubic feet.

[illegible] the rate of cost per mile on the above data is as follows.

Mean total annual expenditure [illegible]
[illegible]
Rate per mile 532 [illegible]

Assuming the discharge per second as the basis of rate, expenditure per [illegible]

Mean total annual expenditure [illegible]
[illegible]
Total cost per [illegible]

The length of the Western Jumna Canal main line and branches is 520 miles, with a discharge per second of 6750 cubic feet.

Taking the above rates on the Eastern Jumna Canal as our guide for obtaining the probable cost of the repairs and current expenses, we have in the present case [illegible] used

Repairs

Regular Establishment	22,467·0
Ordinary Repairs	2,1[illegible]·2
Total Current Expenses per an.	2,36,9[illegible]·2

For the 2nd when discharge for second is considered

Regular Establishment	21,115·0
Ordinary Repairs	2,98,8[illegible]·5
Total Current Expenses per an.	3,1[illegible]·5

As the action upon the channel is dependent entirely on the mass of water with which the banks are [illegible], and as the amount of repairs depends upon this action, we may ad[opt] [illegible] the total as shown in the latter Table as the most likely to be correct; at any rate that the amount there stated will likely be a probable [illegible] annual current expenses of the Canal. I would, however, take the mean between the two [illegible] as the amount to which the annual cost of the repairs and Establishment of the Canal might be limited. I would put the sum of 1,75,000 Rupees, on which the details for Regular Establishment and Ordinary Repairs would in the proportion shown in the Table for the discharges given:

Regular Establishment	[illegible]
Ordinary Repairs	[illegible]75000
Total Current Expenses	1,75000

In the early years of progress, we may say for the first

15 the

5 years after water has been admitted, there will probably be many contingent expenses which may call for extraordinary outlay. The large quantities of [illegible] that will be required for the [illegible] flumes and for the repairs of [illegible] of [illegible] in the [illegible] probable strengthening of the protection works on the upper [illegible] and [illegible] necessary diversions to the [illegible] [illegible] in that portion of the line where it passes through the deepest part of the valley, together with additional protective works which may be desirable on the [illegible] rivers below the [illegible] dams [illegible] appear to me to render [illegible] the available sum expressly for these purposes very desirable. I would rather [illegible] to possibilities of additional cost, and [illegible] pointed the places to which [illegible] [illegible] [illegible] because of [illegible] contingencies [illegible] [illegible] provided for. [illegible] I would suggest, that for the first 5 years after water was admitted an annual sum of [illegible] in addition to the amount of annual expenses estimated for above, should be placed at the disposal of the [illegible] of the works for Contingent

proposed.

I have thought it necessary to devote a section of this Chapter to the above although I feel that in so doing I am dealing with a subject which must to those acquainted with it, appear to be of a very speculative character; the figures however having been employed without attention being directed to cost of maintenance, and as the data upon which my figures have been derived are given, the same will be understood [illegible] successor [illegible] [illegible] the [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] and accordingly.

P^d^

I must conclude this report with an offer of my best thanks to those who whether above or below me have so consistently aided the Progress of the Ganges Canal works from their commencement up to the present time.

From those above me, I have met with an indulgence & consideration for which I can never be too grateful.

From those below me, a readiness of assistance & sympathy under all difficulties that have from first to last been the most cheering part of my service.

Through so many years of progress, & with such a variety of works carried on under circumstances more or less understood the Executive Engineers & officers in the different localities have largely aided me with their advice suggestions and recommendations & for these I am greatly indebted. I have endeavored in the above report to place to the credit of every one, the merit which appears to be his due. Should I have failed in doing this in any individual instance I trust that the omission will be pardoned.

To Col Baird Smith who ~~I trust may long endeavour for me~~ succeeds me ~~in charge~~ in the Directorship of the

Ganges Canal works, & to my excellent friend Mr. Harry Marten, who from the period of the early surveys of the Canal up to the present time, has been constantly with me, I have to offer my best thanks. From the first I have to acknowledge the aid afforded to me in looking over & correcting ~~[illegible] of this report~~, & from the second for undertaking & completing the arrangement of the Plans & Manuscripts preparatory to their despatch to England.

To Colonel W. E. Baker of the Bengal Engineers whose name appears so often throughout this report, whose aid I can never be too thankful for, & whose friendship has been one of the bright lights in my Indian career, the last words of this report are dedicated.

Postscript. These Pages cannot be closed without a passing lament over the memory of those who have been lost to us by the events of 1857-58. Captain Edward Fraser — Capt. Francis Whiting, the first shot by his own men at Meerut, the last most cruelly murdered in the boats at Cawnpore, Lieutenants Frederick Angelo — Brownlow — Span all in the prime of life knocked down by this horrible Mutiny.

London
Sept. 1/62 —

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B Report of a Committee assembled by order of the Right Hon'ble the Governor General of India to enquire into the unhealthiness of Kurnal, and the probable effect on health to be produced by the Ganges Canal.

C Manner of keeping Accounts in the Canal Department and [illegible] 18[illegible]

D General Instructions to Executive Officers of the Ganges Canal Works, by Major W. E. Baker.

E Major Baker's Report on the Ganges Canal Works [illegible]

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G Tabular Statement of Measurements of Hindun [illegible]

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I Table of Depression of Arches on Striking Centres.

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List of Appendices

NORTHERN OR 1ST DIVISION

BRICK-MAKING.

This Division [illegible] the Works were in progress [illegible] of the first Division [illegible] commenced the [illegible] Reader [illegible] of these works, and [illegible] that a sufficient number of bricks [illegible] manufactured [illegible] in India [illegible] operations [illegible] data [illegible] of future undertakings of a [illegible] nature.

The following [illegible] were [illegible] to [illegible] provided; [illegible] hills [illegible]

[illegible]

and partly from the Estimates where Bills have not been submitted. –

Works	Cubic Contents in Feet.
Regulating Works, Chats, Footbridge &c. at the head of the Canal.	520,101
Bridges at Runkhul, Jowallapoor, Peeran Kulleeur, Dunish roor	567,540
Falls at Behadoorabad, Nos 2 and 3 and Salee [illegible], No 5.	1,275,153
Locks at Do. Do. Do. for navigation	285,061
[illegible] passages at the Ranipoor and Puthri [illegible] including the [illegible] Falls Locks &c. [illegible] with them	3,250,237
[illegible] Works in the [illegible] of the Kulwi [illegible] including the [illegible] and [illegible] Bridges	1,421,668
[illegible] Works including [illegible] Bridges at [illegible]	10,992,778
Falls at Hurdwar, Kunkhul and Behadoorabad.	301,443
[illegible]	
Falls &c. [illegible] Kunkhul, Jowallapoor, [illegible] and Roadsbahpoor.	173,934
[illegible]	953,625
[illegible] for the accommodation of Establishments Offices &c.	125,000
Grand Total Masonry	10,866,540

From a further abstract it is found that of this mass of Masonry the following quantity is employed in Brick. –

Pukka Brick [illegible] — Do. — [illegible] Bridges [illegible] Glass Masonry	17,148,714
Total Pukka Brick Masonry	17,148,714
[illegible] Brick Masonry	542,375

And if we add to these the Pukka and Kutcha Brick

Brick masonry contained in the Civil Engineers College Buildings, the Lunatic [illegible], the Station Church, Buzaars, Road Bridges, and the private dwellings of the Subordinates attached to the Division, for the whole of which Bricks were supplied from the Government manufactories, we obtain an approximation to the Total Quantity of Masonry for which the Brick Manufactories had to furnish Bricks.–

	Pela Brick Masonry cubic feet	Pukka Brick Masonry cubic feet
On Ganges Canal Works	542375	17,148,714
Civil Engineers College Buildings, Church, Buzaars &c	629,200	419,441
Private Dwellings	390,000	75000
Totals	1,561,575	17,643,155

and this is, moreover, independent of an immense quantity of Broken Brick which was used in ballasting the lines of Railway, [illegible] roads, &c. &c. the extent of which cannot be [illegible]mated.

From the condensed abstract at the end of this paper, it will be seen that the actual number of Bricks manufactured for the construction of the Masonry above exhibited has been:–

Pukka Bricks of all sizes	1807,79,542
Pela Do Do	307,44,988
Grand Total number of Bricks	2115,24,530

Work in Brickmaking was commenced in this Division in January 1842 under the management of Mr Thomas Wright

and

[illegible] Canal Department. The course at that period was to establish as many kilns as possible at every available village in the vicinity of the line to be taken up for the Canal, and these kilns were to be of the ordinary pattern of "Puzawa" [illegible] now in constant use with the natives of India. For the working season of 1841/42, the [illegible] reported that he had obtained contracts for the manufacture of bricks to the extent of [illegible] Lakhs, and had commenced on a small scale upon kilns independently of contractors; the principal portion of the fuel used in which, was wood obtained from the neighbouring Jungles. On the 1st March 1843 the executive control of this Division was assumed by Lieutenant [illegible] of the Bengal Engineers, and at an early period, he reported that for the season of 1842/43, 63 kilns were in progress of burning under contractors. For the season of 1843/44 contracts were made for 133½ Lakhs, and for the season of 1844/45 the contracts in existence amounted to 1[illegible] Lakhs. For the season of 1845/46 the [illegible] contract rates were Rs 3.5.0 for pukka bricks 12"×6"×2", and Rs 2.0.0 for Pila bricks of the same dimensions. Lieut. Fraser considering that a thickness of 2 inches was too little for the length of the brick, made all his contracts for 2½ inch at Rs 4.3.5 [illegible] for Pukka and Rs 2.8.0 for Pila bricks, only such pukka bricks being paid for at this rate as were taken for use on the works.

During the last mentioned working season (1845/46) Lieut. Fraser perceived that the total outturn of pukka bricks had been quite incommensurate with the advances of money that had been made, and he determined not to enter into fresh contracts until the accounts of the

[illegible]

[illegible] [illegible] [illegible] [illegible] cleared off: this, however, as will [illegible] hereafter was never accomplished. At the latter end of 18[illegible] Lieut. Strachey was called away on field service with the army of the Sutlej, and on his return, the state of his health obliged him to proceed to the Hills on Medical Certificate; his place being filled by Lieutenant [illegible] Yule of the Bengal Engineers.—

The final results of Mr [illegible] and Lieutenant Strachey's operations from [illegible] 1842 to June 184[illegible] [illegible] [illegible] [illegible] were as follows:

Advances [illegible] [illegible] [illegible]	79,666 13 1
Expended in Department [illegible]	186 9 13 6
[illegible] to [illegible] ([illegible] [illegible] [illegible] [illegible])	3343 6 9
Stacking	761 6 8
Establishment and [illegible]	1437 12 11
Total Amount of Expenditure Co's Rs	90[illegible] 7 6 11

The [illegible] [illegible] Bricks for the above Expenditure was:

Description	[illegible]	[illegible]
Pukka Bricks [illegible] [illegible] [illegible]	[illegible]	[illegible]
Do [illegible] [illegible]	[illegible]	64,00,[illegible]
Total Pukka Bricks	[illegible]	72,[illegible]
[illegible] Bricks used in [illegible] [illegible]	[illegible]	13,[illegible]
Do [illegible] [illegible]	[illegible]	37,50,000
Total [illegible] Bricks		[illegible]

Grand Total [illegible] [illegible] [illegible],406

and the actual cost of the Bricks was [illegible] [illegible]

Pukka Bricks	12 x 6 x 2	at the [illegible]	[illegible]	650	per Lakh
Do	Do	[illegible]		710	Do
Do	12 x 6 x 2½	[illegible]		770	Do
Do	Do	[illegible]		1000	Do
[illegible] Bricks	Average			[illegible]	Do

which for Pukka Bricks is considerably [illegible] [illegible] of the rates at which Contracts had [illegible] [illegible] [illegible]. The Department [illegible] upon [illegible] [illegible] [illegible]

Rupees 1509.13.6 had been expended, were entire failures, and this being known to Lieut. Stracher as soon as he joined, he discontinued the experiment. Setting this amount aside, and confining ourselves to the Contractors accounts, we find that

The Amount to Contractors was Co's Rs 79666.13.1

Value of Bricks at the Contract rates

30765350 Pukka 12 x 6 x 2	3.550 p lakh	10,766 [illegible]
1195590 Pila do	2.200 p do	2384.9.5
7259921 Pukka 12 x 6 x 2½	3.450 p do	31,450.2.6
3923290 Pila do	2.250 p do	9839.13.7

Real Value of Bricks Co's Rs [illegible] 7 0

Lost by Contractors Co's Rs [illegible]555 7

With one exception the Contractors against whom balances existed were men of straw, every effort was made to get them to fulfil their engagements or to refund, but all failed, and it was determined by Major Baker, the Director at that time, that legal proceedings instituted to prove [illegible] would [illegible] the addition of a [illegible] amount for law expenses to the heavy losses which had already been sustained.

The failures on the part of most of the Contractors were undoubtedly due to the following causes.

1st The impracticability of obtaining from the villages situated within the small circle to which our operations were necessarily confined, a sufficient quantity of the requisite fuel with which to burn the large number of bricks provided.

2nd The neglect on the part of the Contractors and their habit of stinting the bricks in fuel unless constantly watched.

3rd To the want of intelligent European subordinates; for a long time Lieut. Stracher had none, and when he did get them they were inadequate

1846 and 1846-47.—

From June 1846 to the end of the working season of 1846-47, the Brick making Operations were carried on under the superintendence of Lieut. Yule. The little success that attended Lieut. Strachey's arrangements for contract bricks rendered it imperatively necessary that we should depend for our main supply of this material on our own kilns burned with wood fuel. The measures adopted for this purpose, and the progress made during this period, are thus described by Major Baker in his final Report on the Ganges Canal works dated 11th January 1848.

"A small commencement of the arrangements for this purpose was made in 1846, after the close of the Sutlej Campaign, but it was then too late in the season to obtain any satisfactory results. In the cold weather of 1846-47 a number of new kilns were built both at Roorkee and Mohunpoor, and considerable quantities of fire wood were cut in the forests and carted to the kilns. During the early part of the season many circumstances combined to render the results of these operations very unsatisfactory. Great pains had been taken to ascertain the method of burning bricks with wood as practised at Umballa and Meerut; but our people did not at first get into the way of loading the kilns properly, and this, combined with a long duration of unfavourable weather, and the greenness of the fire wood rendered the operations of the cold weather almost entirely unprofitable. At the commencement of the hot season, however, an improvement [illegible] began to appear, [illegible] descriptions of kilns were tried with better success, and before the setting in of the rains, we had turned out about 33 Lakhs of admirable Bricks from

it.

the English Kilns".–

The first description of English Kiln tried at [illegible] was [illegible] with considerable success by [illegible] at [illegible]; it failed however with us, and this may be attributed to three causes

1st. Using Teak wood instead of Babool or other hard woods.–

2nd. Using [illegible] instead of the light Chuppa grass [illegible] of Umballa to [illegible] the surface of the layers of wood.

3rd. Ignorance of the proper management of the fire by means of the vents and the surface covering of ashes.

The Second Indian attempt was that described in the [illegible] Vol: III [illegible] practised in [illegible]; the consumption of wood is greater than in the first experiment, and the result none so satisfactory.

The third experiment was made with a [illegible] kiln [illegible] with [illegible] bricks were obtained [illegible] rolled out, but not in a perfection that would warrant a second trial.

The Clamp method was introduced [illegible] passing through Roorkee, who offered to take service as a Brickmaker. His plan was [illegible] and [illegible] understood its management, the produce of his kilns was comparatively good.

The [illegible] method was taught us by [illegible]; it was less [illegible] than the [illegible] method, and more dependent on the quality of the wood, but the bricks are more [illegible] and of better quality.–

A more detailed account of the [illegible] of wood in the kilns above alluded to will be given when the [illegible] are under discussion.

Sixteen kilns of the above pattern

as

as also the small [illegible] kilns [illegible] of [illegible] [illegible], and [illegible] established 3 Hindostanee Kilns under the supervision of Government servants. The first system, [illegible] the [illegible] instance out unmitigated failure, the whole of the bricks being [illegible]. The total number of Pukka Bricks moulded was 67½ Lakhs, distributed thus:—

Loaded in English kilns	[illegible]	49·8
Do. [illegible] kilns		[illegible]
Do. Hindostanee kilns		[illegible]
Remained in [illegible] kilns		[illegible]
Wasted by rain, &c.		2·7
Total Lakhs		67·5

and the total outturn [illegible] was:—

Pukka bricks	Lakhs	[illegible]
Peela do.	"	[illegible]
Surkee	[illegible]	[illegible]

The Cost of these, including construction of kilns, clearance of ground, opening out of roads, and all the implements requisite for this sort of work, was

Company's Rupees 1,38,7[illegible]

which gives the following rates for the manufactured material:

Pukka bricks taken at [illegible]	[illegible]	[illegible]	Rupees	[illegible]	per [illegible]
Peela	do.	¾	[illegible]	400	[illegible]
Do.	do.	½	[illegible]	250	[illegible]

The Cost of turning out the moulded and dried Bricks was approximately Rupees [illegible],509, and consequently the cost of Pukka Bricks was

Company's Rupees 11 [illegible] per lakh

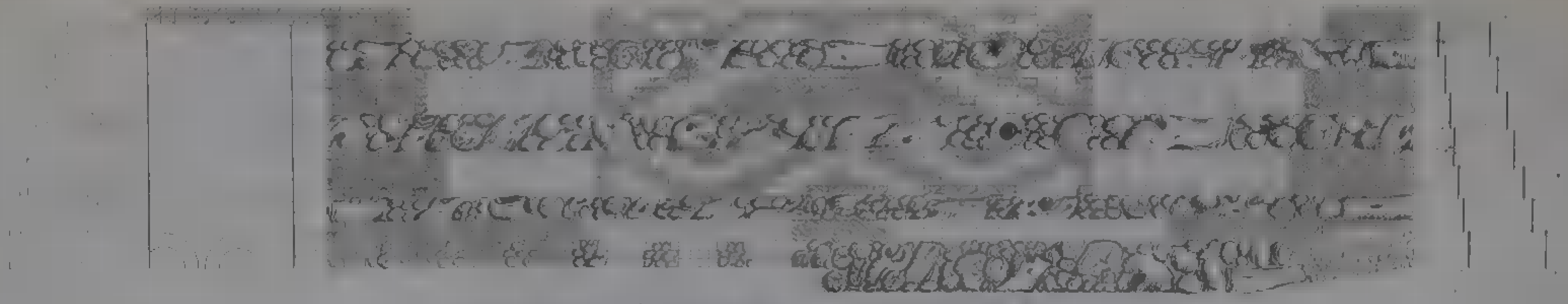
Besides the 49·8 Lakhs shown above to have been placed in the English kilns, there were 13·5 Lakhs of Peela bricks re-burned in the kilns, making a total of 63·3 Lakhs, from which were [illegible] only 51 Lakhs of Pukka

Pukka Bricks [illegible] the [illegible] of the whole number. The results of the Mountain [illegible] were good, being 32 Lakhs of Pukka Bricks out of the 42 Lakhs; [illegible] had it been possible to burn these [illegible] with little or no [illegible] instead of the most expensive [illegible] which is known [illegible] had to be [illegible] to make up the deficiency, they would have been cheaper still.

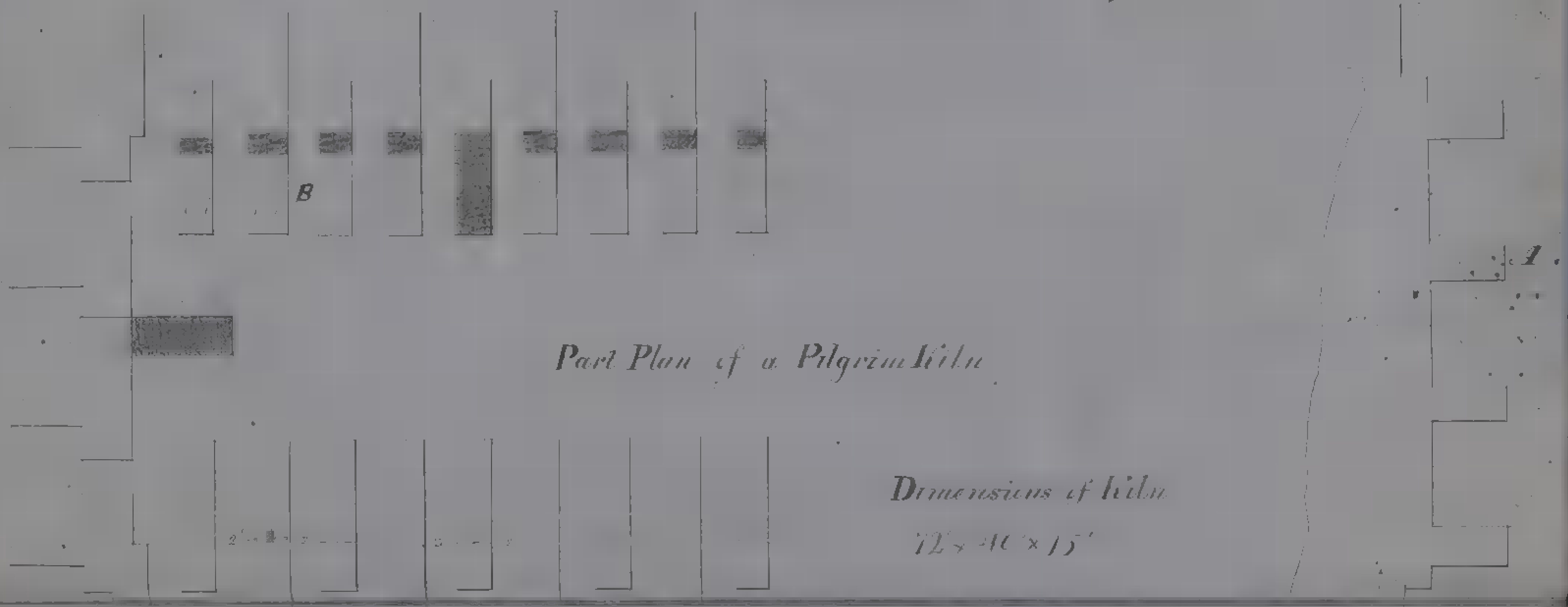
The [illegible] during the season [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] through great [illegible]

[illegible] [illegible] [illegible] [illegible] has had to struggle with many difficulties [illegible] [illegible] [illegible] [illegible] [illegible] he has [illegible] the [illegible] [illegible], has doubtless [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]; [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] past and future [illegible] [illegible] [illegible] attribute [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] future [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the results [illegible] [illegible] Predecessors [illegible]. The power required to maintain the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] required to [illegible] it [illegible]!"

Part Elevation and Longitudinal Section of a Pilgrim Kiln



A Longitudinal Section on the Line B.A



Part Plan of a Pilgrim Kiln

Dimensions of Kiln

72' × 40' × 15'

Sheet No. 2.

Sketch

of

PILGRIM KILN

Transverse Section of a Pilgrim Kiln

Section on the Li[illegible] AB

Scale of [illegible] Feet an Inch

Copied by D. Hallbern 2 July 1853

The commencement of the working season of 1847/48, found a [illegible] new era in the works on the Ganges Canal. The Government had by this time determined to [illegible] [illegible], and all the former restrictions as to the amount to be expended annually were taken off. The works about [illegible] this time were considered amply sufficient for the supervision of the Executive Engineer; and a separate Officer was appointed for the manufacture and supply of material. The Officer entered upon the latter duties in October 1847.

The first [illegible] that existed in the area [illegible] made by [illegible] with regard to the relative situations of the moulding grounds, [illegible] and [illegible], but as these had been [illegible] working under the Executive Engineer [illegible] it was [illegible], [illegible] not then [illegible] to rectify them; the Officer, therefore, [illegible] with the [illegible] and kilns as left by [illegible] and made the improvements [illegible] gradually; [illegible] the end of the season [illegible] "Gulé" kilns were almost entirely superseded by new ones built more substantially and situated in [illegible] proximity to the drying grounds. The operations were conducted with variable success, and always at a heavy expense; [illegible] the turn out of [illegible] Bricks was [illegible] highly satisfactory as compared with the results of former years, and a method of burning was hit upon which seemed to promise well for the ensuing season. Four Hindustani kilns were established on the Roorkee works under the supervision of the Government Establishment and [illegible] successfully [illegible]; and [illegible] other kilns of this description were set in progress [illegible]

[illegible]

have been [illegible] by Government [illegible], at [illegible] within a reasonable distance from the towns where the appropriate fuel was obtainable.

The different systems pursued by the [illegible] may be described thus; [illegible] a [illegible] of [illegible] figures [illegible]

1st or "PILGRIM MODE," Vide Plan [illegible] Sheet No. 2.

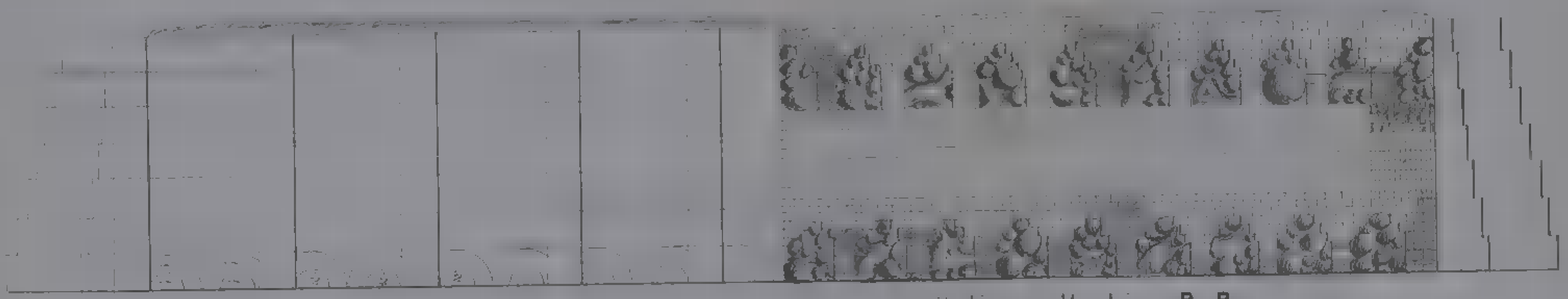
This mode takes its name from the Pilgrims' [illegible] of [illegible]. The floor of the kiln is hollowed with a [illegible] of 1½ [illegible] side sloping to the [illegible] of the [illegible]. The flues are at 2 feet intervals, [illegible] and are carried 2 feet towards [illegible] side of the kiln; at that distance [illegible] and the [illegible] is packed with wood to the top of the flues; the [illegible] of bricks are then laid on edge, and over that the wood and bricks in alternate layers. The results of the kilns fired on this system [illegible], the average [illegible] was [illegible] of [illegible] Bricks [illegible], but the greater number of the [illegible] were [illegible] and the bricks [illegible] the walls of the kiln [illegible] and [illegible] was [illegible]. Great damage was done to the walls of the kiln by the [illegible] pressure of the bricks against them [illegible] as the wood was consumed. [illegible] this system [illegible] a little hope of success.

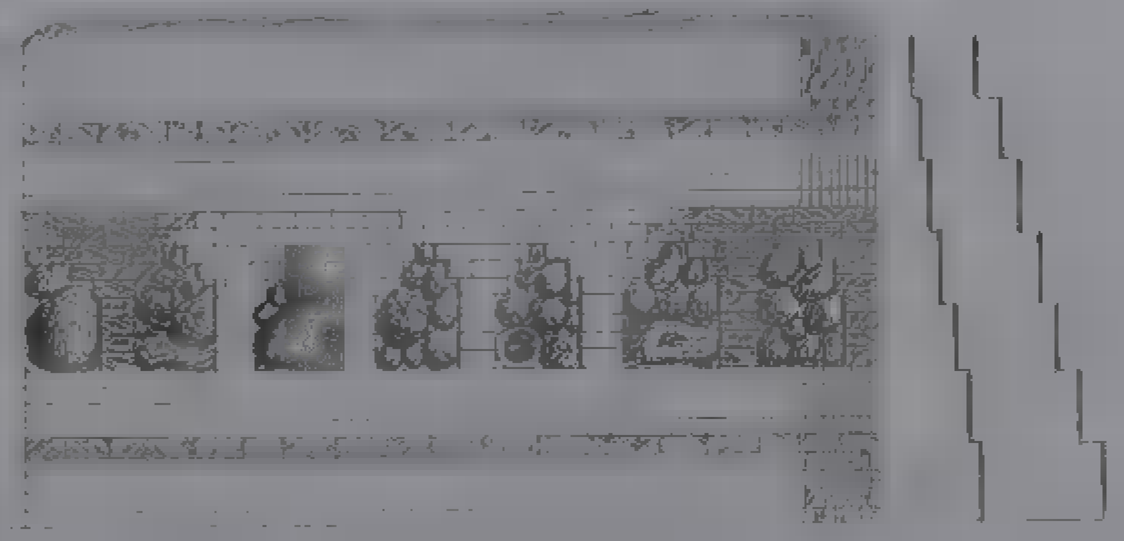
The Quantity of Firewood used for [illegible] 10 [illegible] was 3300 maunds.

IInd or "BENARES MODE" Vide Plan [illegible] Sheet No. 3.

The floor of the kiln is [illegible] and the bricks are then packed in tiers or arched.

BENARES STYLE

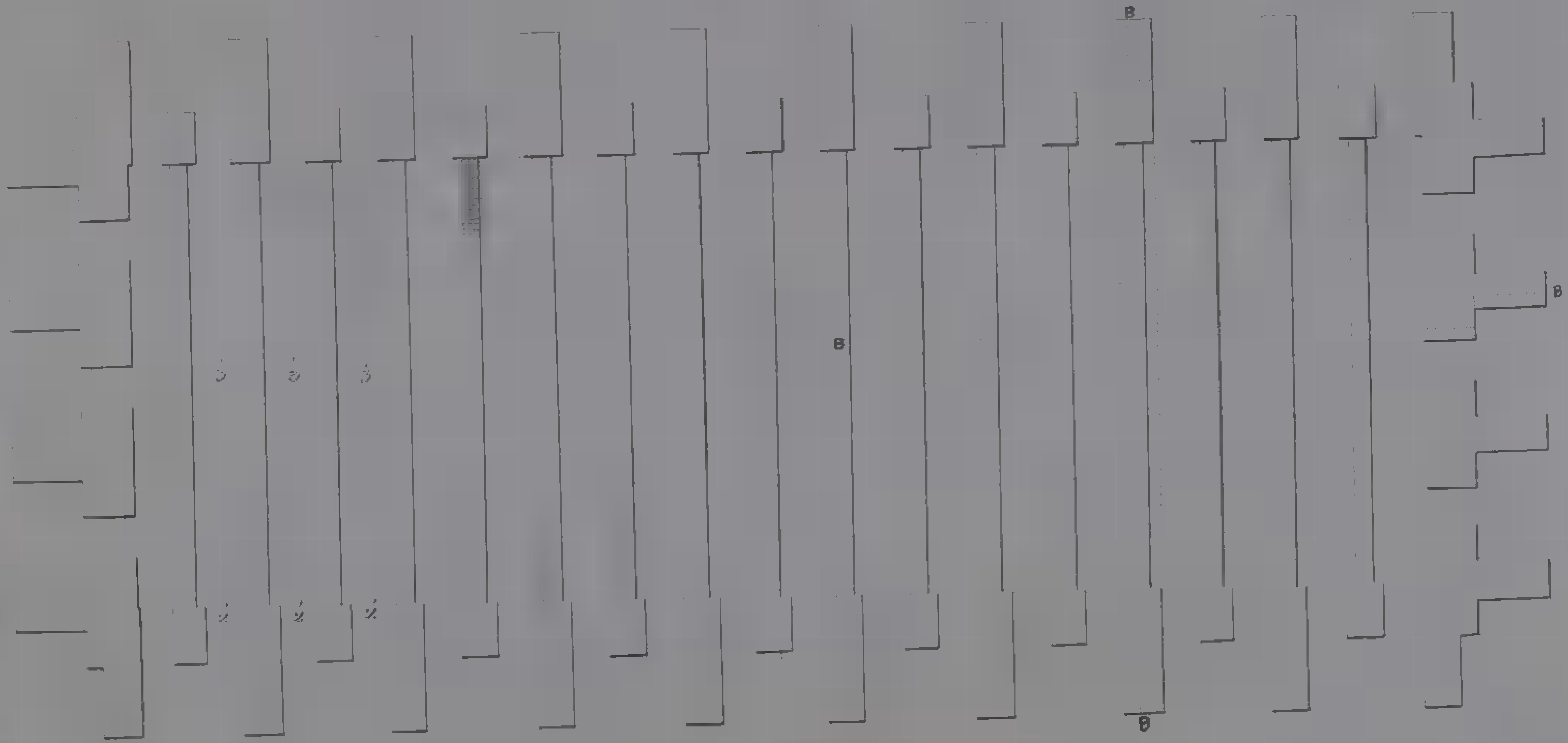




Scale of 7½ Feet to an Inch

Sheet No 3

PLAN



Scale 7½ Feet to an Inch

Copied by Mooshtaq Ahmud
6th July 1853

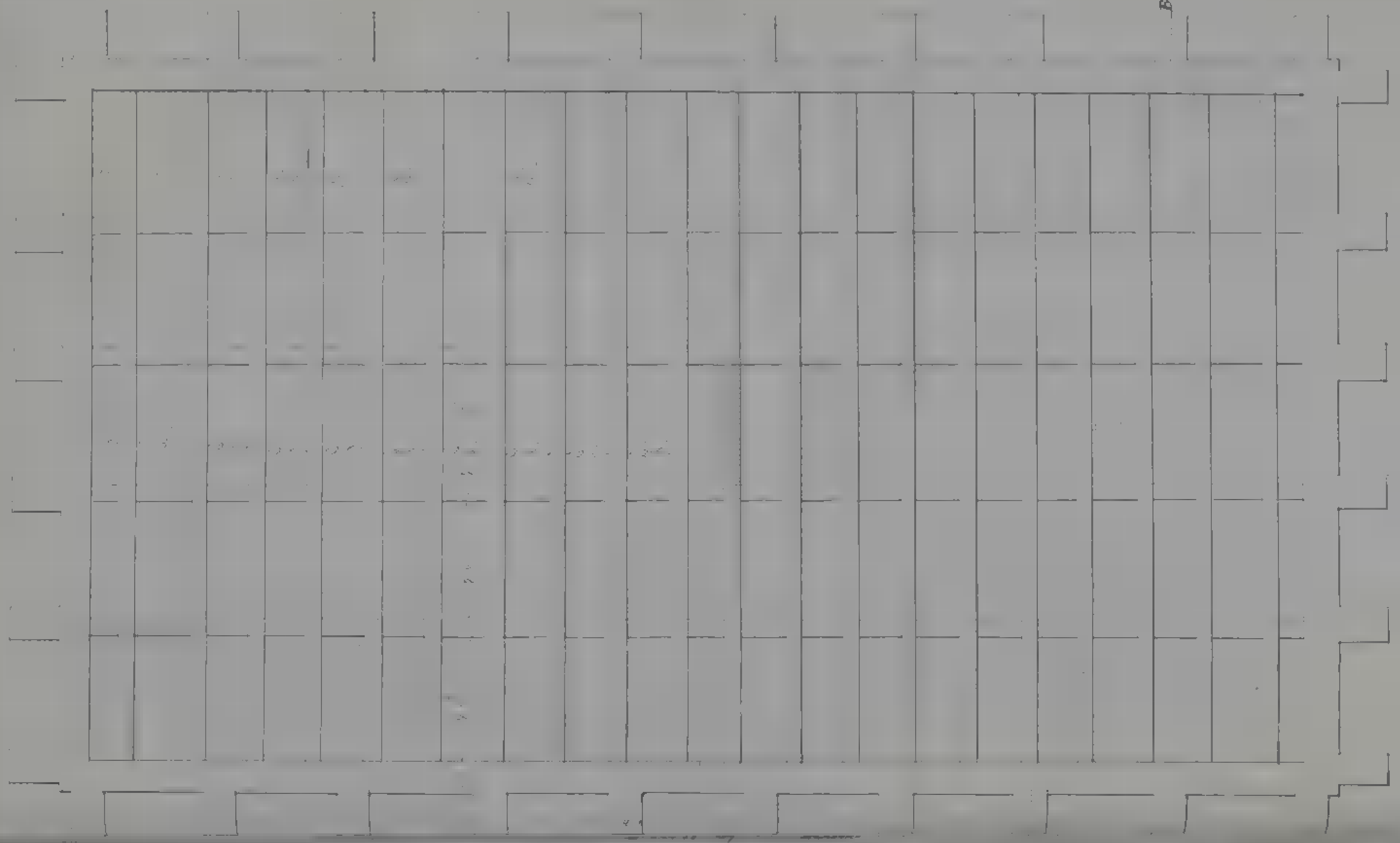
Sheet No. 4

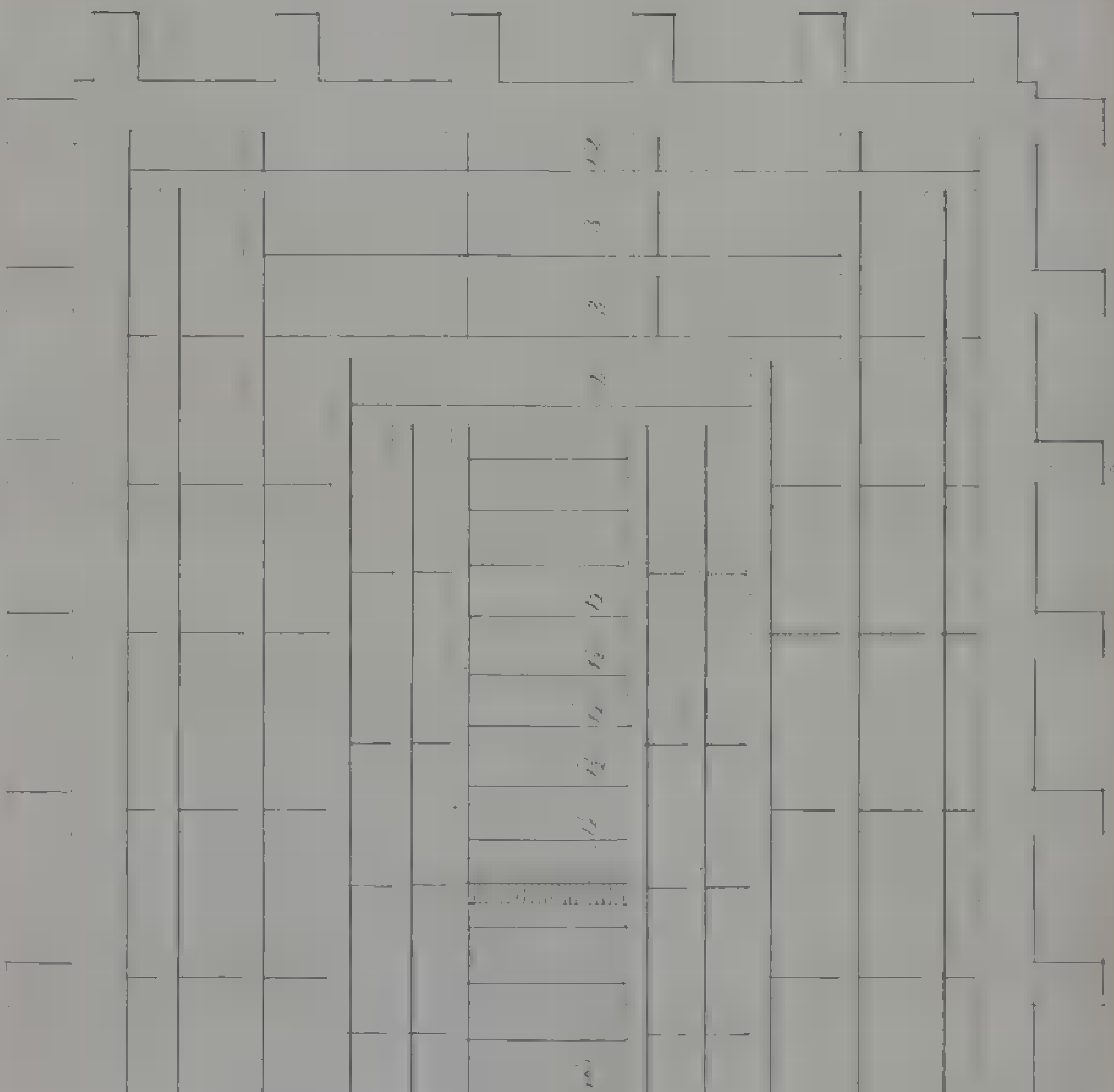
Sketch

of the

MODIFIED BENARES KILN

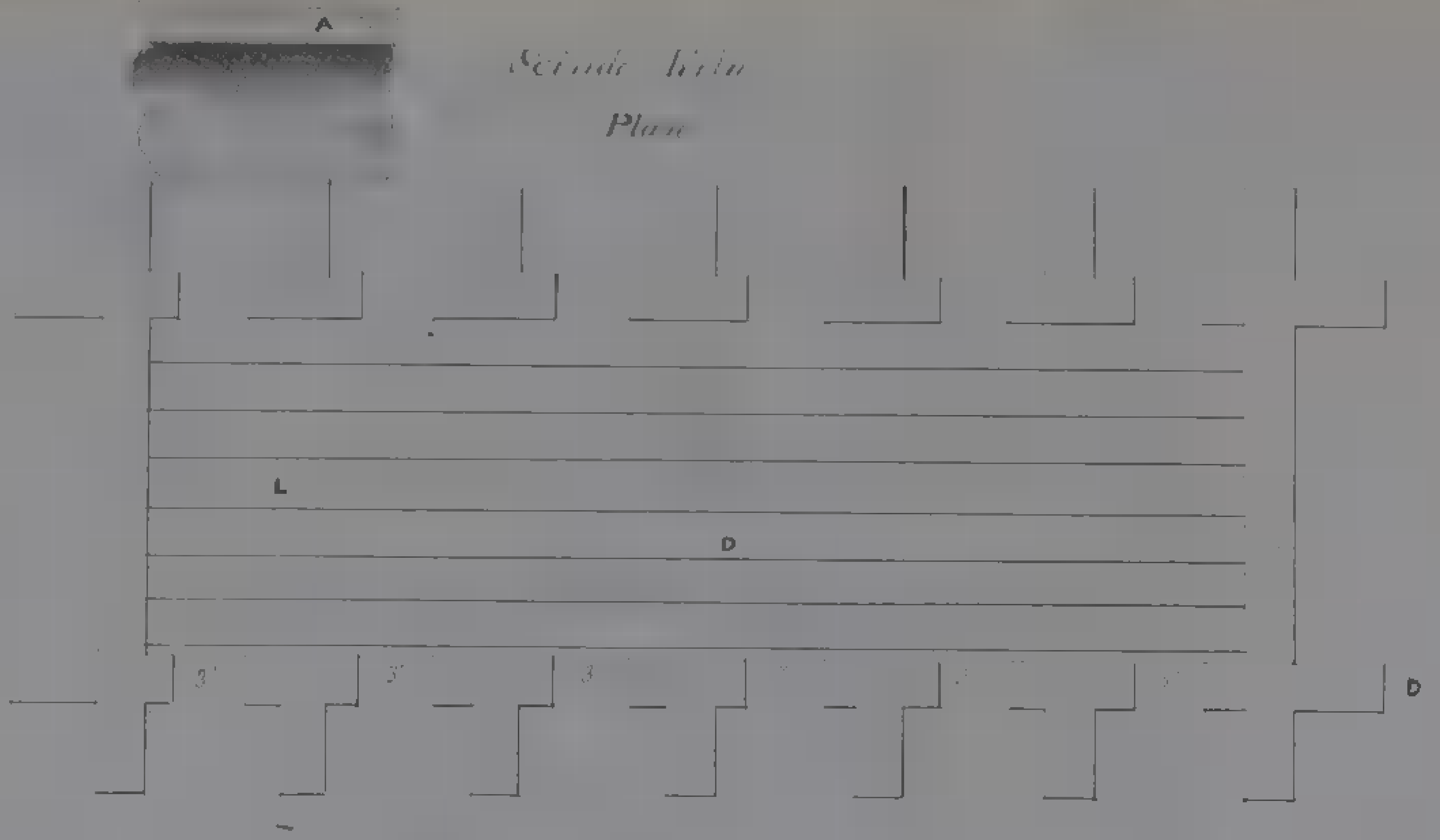
Plan of 5th Row



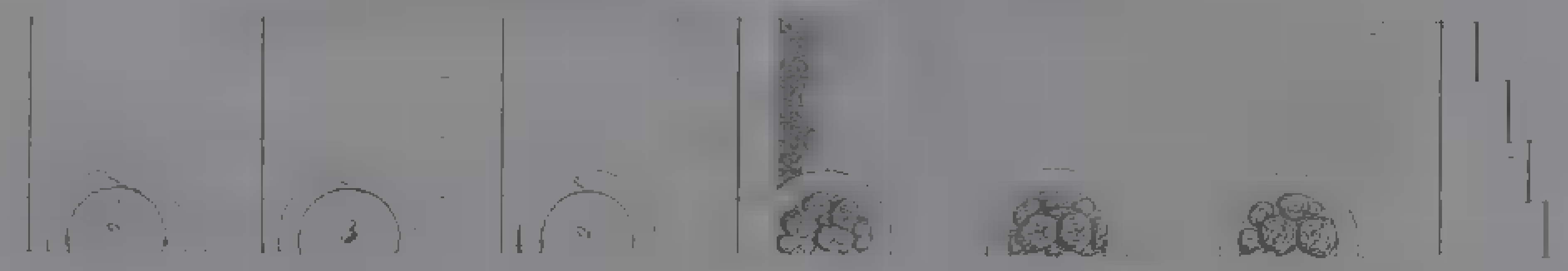


Scinde Kiln

Plan

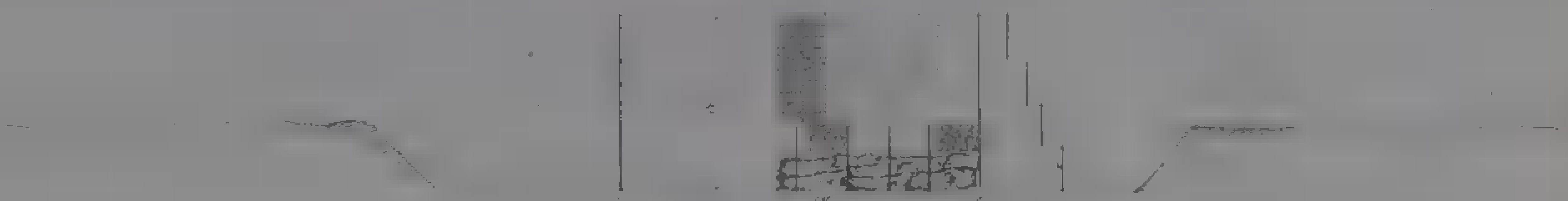


Longitudinal Section and Elevation



Section on the Line **D D**

Transverse Section



Section on the Line A L

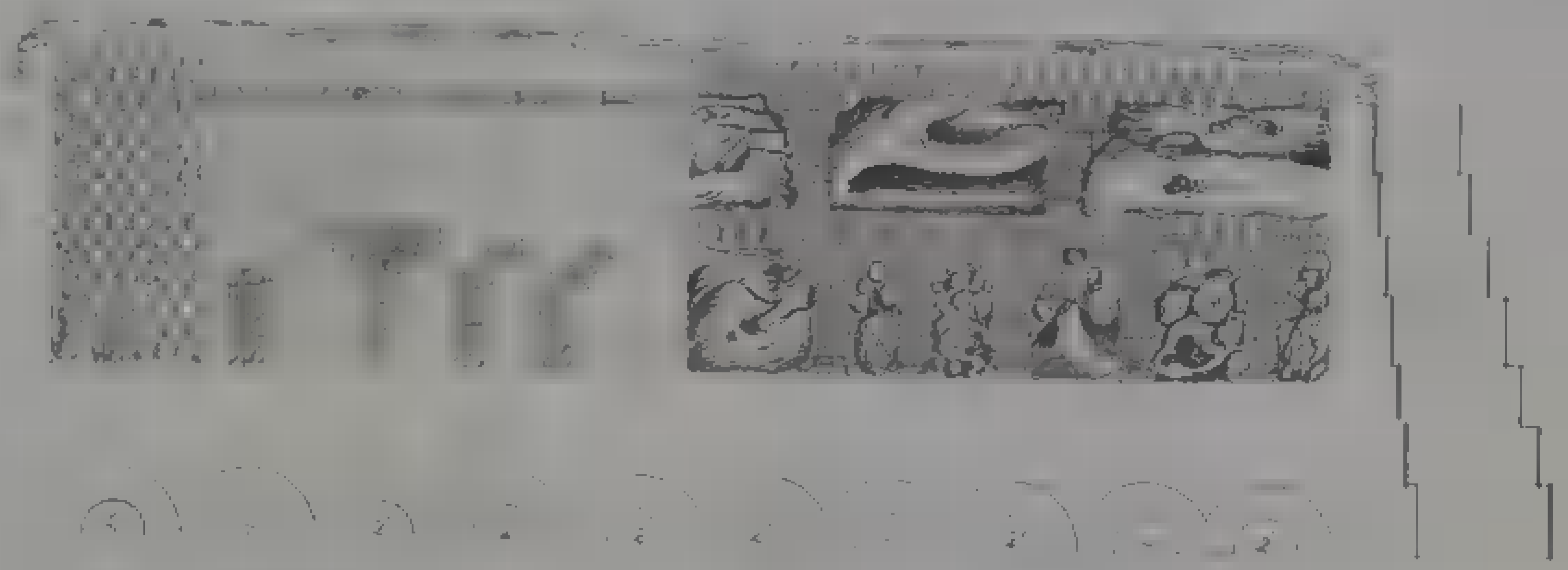
Sheet N^o. 5

Sketch

of a

SCINDE FLAME KILN

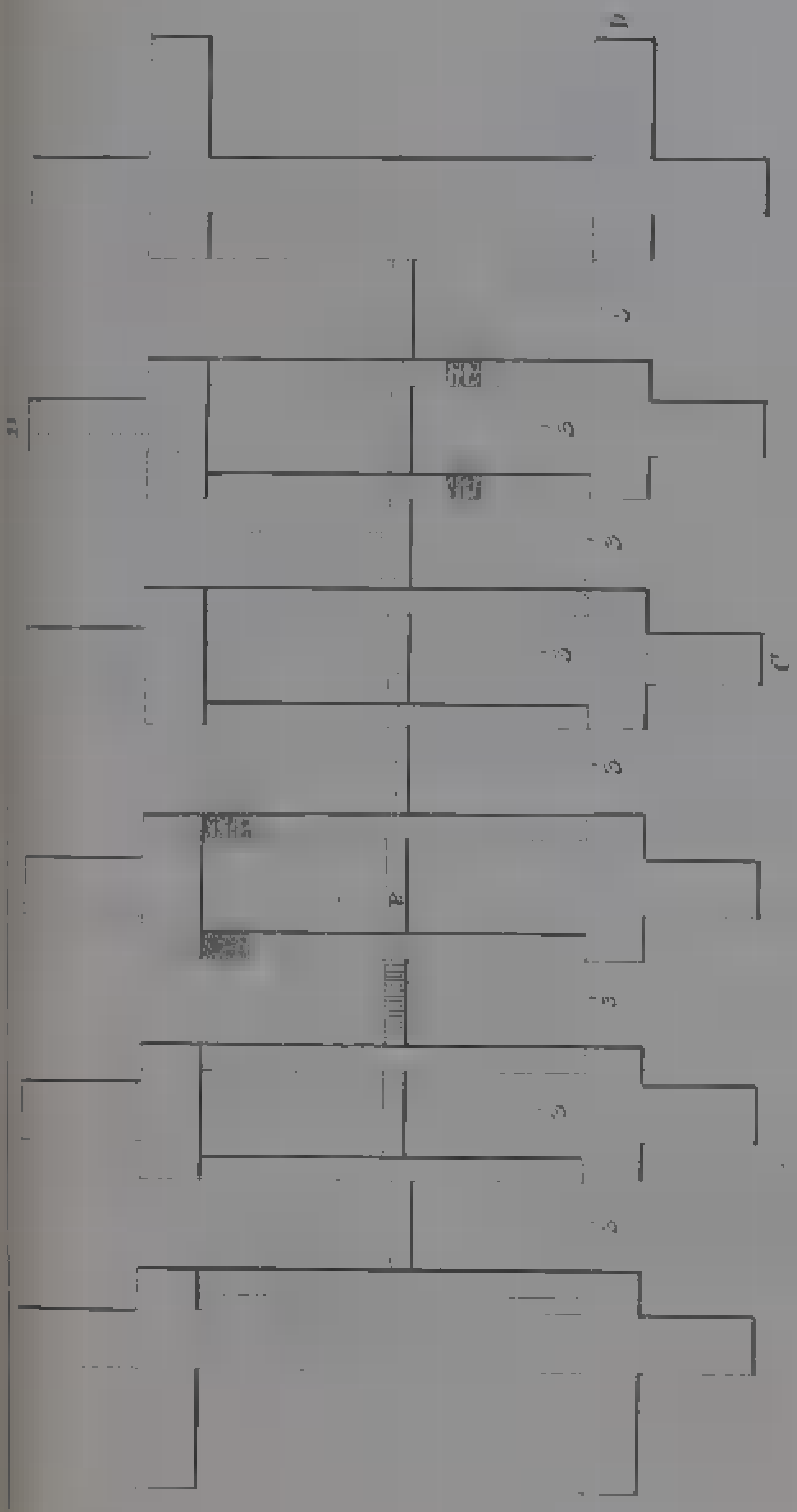
Transverse Section of 2nd and 3rd Rows

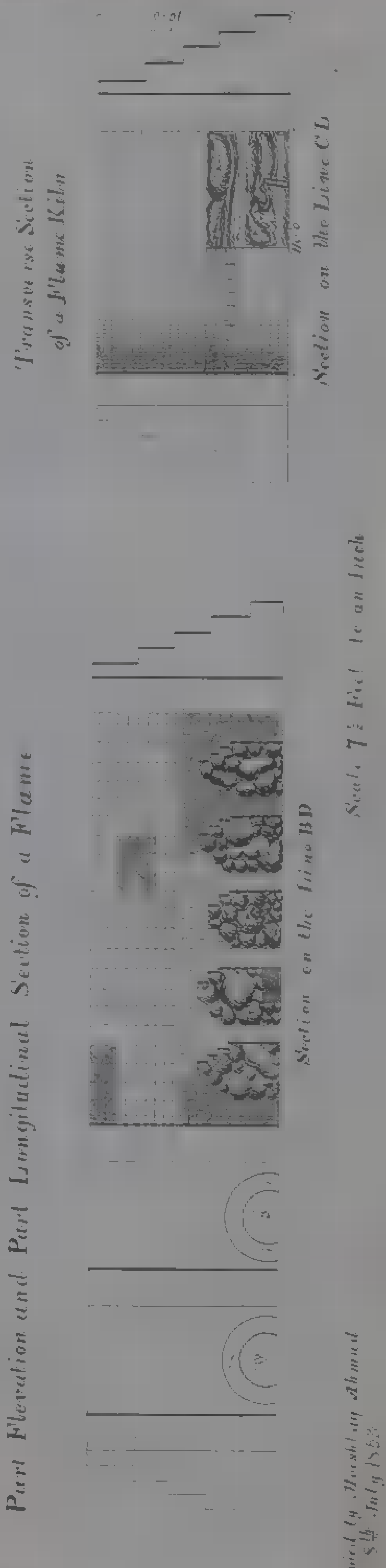


2nd Row Section on the Line C L
3rd Row do C B

Sheet No. 6

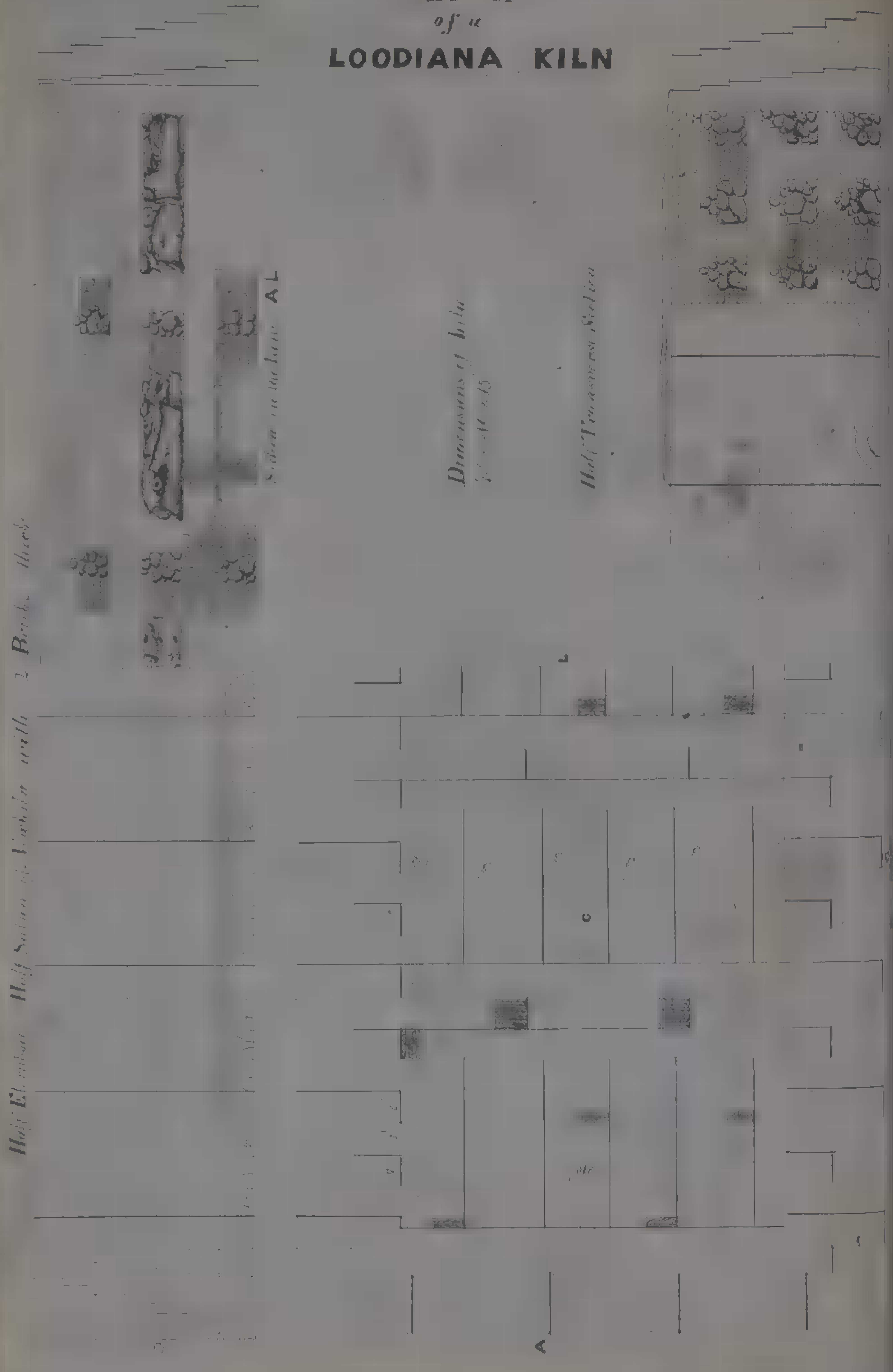
Sketch
of a
ROORKEE FLAME KILN

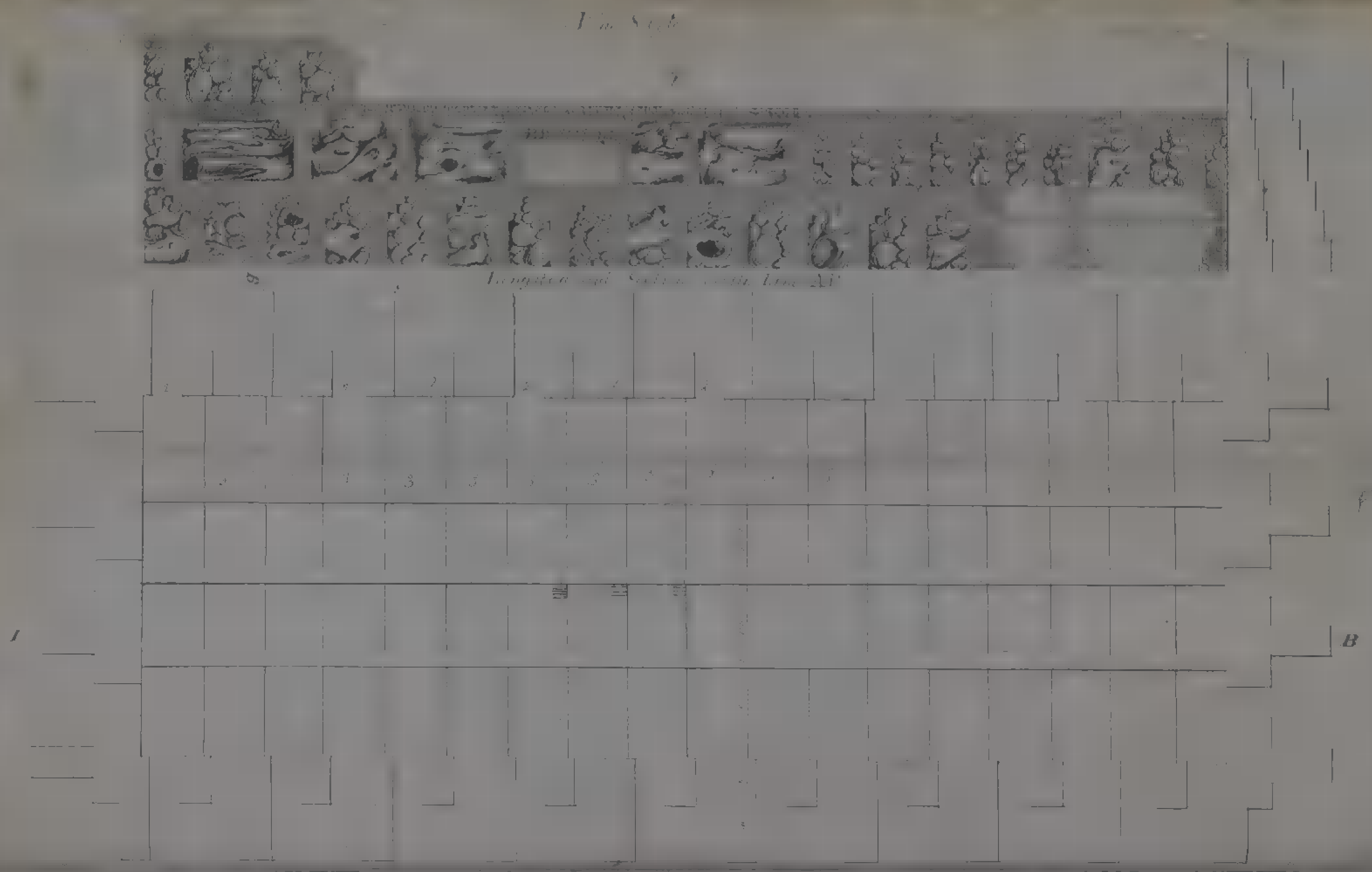




Sheet No. 7

Sketch
of a
LOODIANA KILN



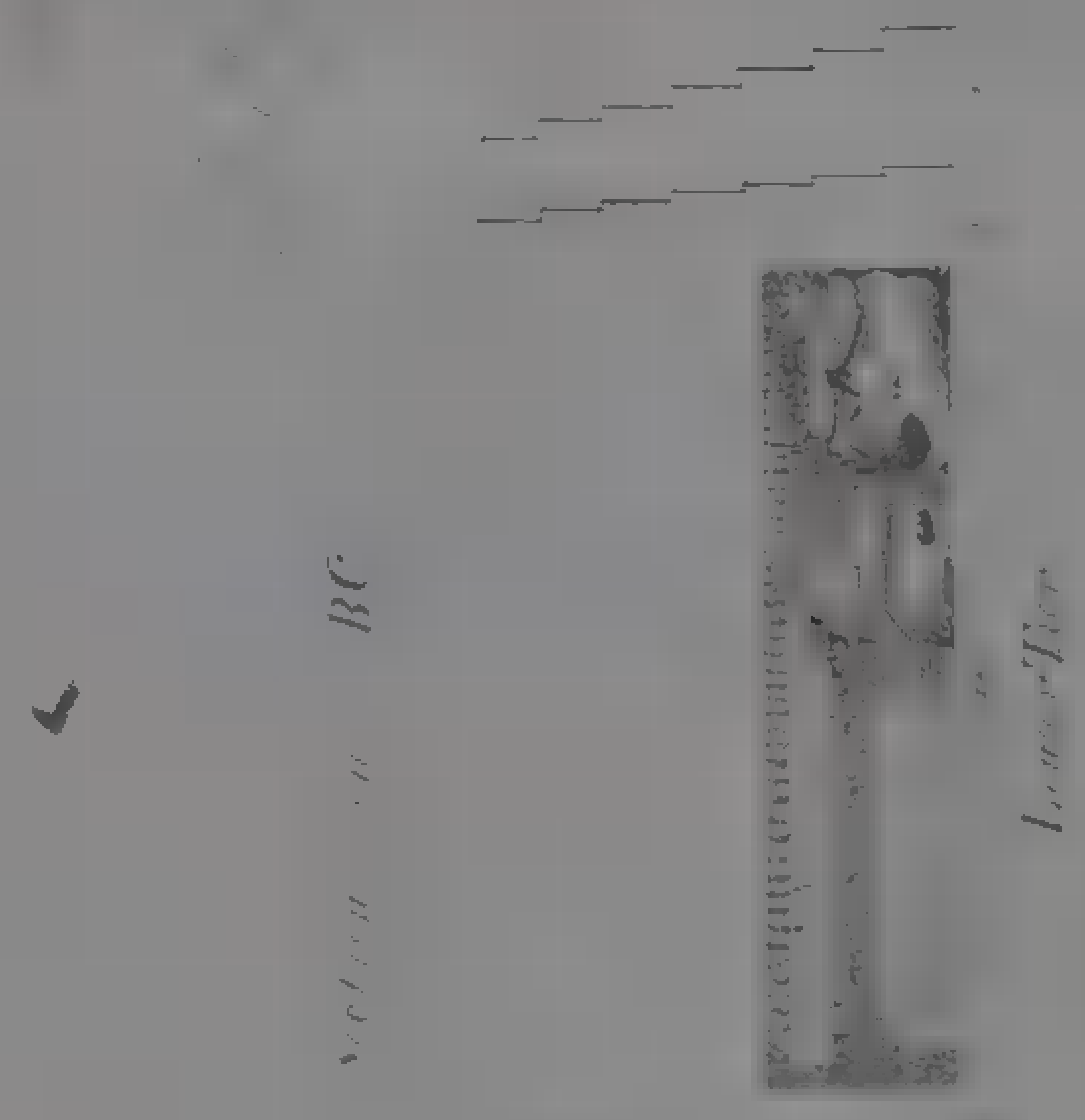


Sheet No. 8

Sketch

of

ROORKEE NEW SYSTEM KILN



arched flues throughout the kiln; the flues are all 3 feet wide at bottom, the piers are 1 foot or one brick only in width, and 4 bricks high, from where the arch is commenced and closed with the 10th tier, making the flues 3 feet high. When the lower tier of flues is completed, a second tier is built thereupon, crossing it transversely; on the 2nd is built a third tier which completes the kiln. The wood is carefully packed into each flue as it is constructed and all interstices filled in with chips. The average result of kilns so filled was 55 per cent of Pukka on the Kutcha Bricks piled. The bricks of the lower tier flues, and many in the shoulders of the arches, turned out pila, whilst in the centre of the kiln large quantities of Jhama were found, owing partly to the want of proper distribution of the wood, and partly to the breaking in of the flues, which drawing the fire to particular parts caused vitrefaction.

The Quantity of Firewood used per Lakh of Bricks was 3200 maunds.

IIIrd: SYSTEM *Vide Plan and Section. Sheet No. 11.*

This was an endeavour made to improve upon the Benares mode: the lower part of the kiln was packed with a tier of flues similar to the Benares method and completed with alternate layers of wood and bricks, the lower layer being always less than the upper one in depth or thickness. In some of the kilns 2 feet of wood, and a layer of 8 Bricks in depth was placed immediately over the flues:– in others, 2 feet of wood and 6 bricks were used and over this to form the second layer 2 feet of wood, and 6, 10, and even 7 Bricks in depth were placed. The average result of this mode was 55 per cent of Pukka Bricks. The lower portions and sides of the kiln were bad, turning out pila and much broken bricks; the lower centre produced

Jhama

Tanvor, whilst the upper centre and the entire upper layer were very good. Damage was done to the walls of the kiln in the same way as to those of the "Pilgrim" kilns.

The Quantity of wood used per Lakh of Bricks was 3300 maunds.

IVTH OR SCINDE FLAME KILN, Vide Plan &c. (Sheet No 5.)

An experimental kiln on this plan was built. its interior dimensions being 20' × 12', and it was sunk 3 feet into the ground; the exterior walls were raised 3 feet high, by 1'.9"; the two side walls were perforated by three arched flues each 3 feet wide, 2 feet high and the centres of each arch were 5 feet apart; these flues were carried across through lines of longitudinal walls built in the interior of the kiln each wall being 3 feet high, 1'.6" wide and about 6 inches apart; it was completed by raising the exterior walls to a height of 8 feet the additional 5 feet being only 1'.6" wide, which left a shoulder, 3 inches in width, on a level with the longitudinal walls for the bricks of the lower line to rest on. The kiln was filled by laying the bricks on edge on the top of the interior walls the flues having been first packed with wood; the first four layers were placed openly the bricks of the lowest one about 2 inches, and those of the 4th about 1 inch asunder the remaining layers required to complete the kiln, were packed closely. The kiln contained 7800 Bricks and was loaded 3 times with the following results

1st Result	56 per cent
2nd Do	71 per do
3rd Do	38 per do (with large well bricks 3 inches thick)

On each occasion it was fired vigorously for 60 hours: when the fire reached the 2nd line of Bricks from the top, the kiln was covered in

by

by a layer of ashes 3 or 4 inches thick.

The quantity of wood used to each kiln was 350 maunds, or about 450 maunds to each lakh of Pukera Bricks.

The advantages in these kilns were, that they were more readily fired than the larger kilns; and the large proportion of whole bricks obtained from them. The disadvantages were, the great expenditure of wood, and the injuries sustained by the arches of the interior longitudinal walls by every firing.

Encouraged by the favorable results of the above described small kilns, Mr Finn tried others on a larger scale, and with the view to economizing the expenditure of wood, and following out the plan of a Scinde kiln with which he had been provided. The centres of the arches or flues were extended from 5 to 6 feet apart, and the interior width of the kiln was made 14 instead of 12 feet. The same process of filling and firing as had been practised in the small kilns were adopted in these, but the results were unfavorable; the out-turn being nothing but 2nd class and pilla Bricks. This plan was, therefore, abandoned. The dimensions of the largest Scinde kiln were 150' × 14' × 8'

Vth or "ROORKEE FLAME KILN." (Vide Plan — Sheet No 6)

It being supposed that the last described kiln failed on account of the flues being so far apart and the advantages of burning by flame being evident Mr Finn determined to try a modification of the Scinde pattern. For this purpose he removed the interior longitudinal walls from the large kiln above mentioned, and increased the height of the interior walls by 2 feet making the kiln 150' × 14' × 10'. Its floor was levelled off and a tier of arched flues 3 feet wide and 3½ feet high was formed from side to side; On the top of these

these flues 6 rows of bricks on edge were placed. The four under layers were rather open, the upper layers close. Every other flue only had an arch, small holes being left in the piers for the fire to communicate. Each of the open flues were divided by a cross wall one foot thick to prevent the wind forcing the fire through the bottom of the kiln.—

The average result from 6 kilns burned during the season was 70 per cent and the expenditure of wood was about 4400 maunds to each Lakh of Kutcha Bricks.—

VI^TH: or, "LOODIANA SYSTEM," Vide Plan (of Sheet No: 7.)

Introduced by a native, who professed to have gained great experience in brick burning under a European Soldier at Loodiana. His system differed from that of the Benares one, in having 2 bricks in the piers of the flues instead of one, and in having one flue open and three closed, instead of firing from the whole. The two kilns fired by this man were great failures, and his system was at once abandoned.

VII^TH: or ROORKEE NEW SYSTEM, Vide Plans, (in Sheet No: 8)

The kilns previously described having been filled time after time without any marked improvement in the out-turn of Pukka Bricks, it became necessary to find out a mode by which better and more regular results would be insured. The Benares system was therefore modified in the following manner.—

Instead of one uniform (width) height of flue, the "Roorkee new system" kilns had flues of various sizes according as experience had taught that they were required. Thus in the lower part of the kiln where Pilla bricks prevailed in the Benares, the new system had flues 3 feet wide and 5'. 6" high. The arch commencing on the

6th

6th instead of on the 4th brick, which gave space for a considerable quantity more fuel. In the centre of the 2nd tier where Danior formed, the flues were reduced to 1½ feet in width, and on each side of these were placed 2 two feet flues, the tier being completed with 2½ and 3 feet flues towards the sides and ends of the Kiln, where in the Benares system "jhela" Bricks were found; the arches of the 2nd tier of flues commenced on the 5th brick throughout and were 10 Bricks or 3 feet in height. In the 3rd tier, the end half flues were made at each end of the Kiln, 3 feet, and all the rest were 2½ feet wide, the arches commencing on the same brick, and being of the same height as in the 2nd tier. The flues of each tier were divided by cross walls into cells of about 10 feet in length, and this was found to be a great improvement, by increasing the number of Bricks in the Kiln, and consequently decreasing the quantity of fuel, and by regulating in some measure the current of wind and air through the Kiln.

The superiority of Kilns filled in the manner just described was soon apparent; a comparison between 6 English Kilns, filled on previous plans, and 6 of the same size filled in the new way gave, to the former, an average return from each Kiln of 35797 whole pukka Bricks or 55·4 per cent; whilst the latter gave 61140 whole pukka Bricks and an average percentage of 66·3: shewing an increase of 11 per cent of pukka Bricks with the very great advantage of nearly twice the number of whole ones. This method was, therefore, continued throughout the remainder of the season, and the best Kiln yielded a percentage of 84·6 of pukka bricks on the Kutcha ones piled into Kiln. The quantity of wood used in these Kilns was about 3000 maunds per Lakh of Kutcha Bricks.

In

On all the English Kilns filled by Mr [illegible] 2 layers of broken bricks were laid flat on the top, and over these Kiln ash was deposited in ridges at first, and spread out when the fire made its appearance at the top of the Kiln. The layer of ashes being from 9 to 12 inches in depth. In firing, the flues were not finished with wood for from 36 to 48 hours after lighting, or until the fire had laid good hold of the Kiln. Various methods of firing were tried, some with every other flue closed; some with one open and two closed, and others with one open and 3 closed flues. The system of 1 open and 2 closed appeared to act the best, as the fire passed more equably through the Kiln than in the others. Two flues were attended and fired by 1 Beldar, and the Kilns were watched day and night for a week after firing, and all the chasms and sinkings filled up with [illegible].

The wood with which these Kilns were fired was Dhak, Pepul, Bunghut, Saul, &c but for the most part was Dhak derived from the above Forests; it was cut by Servant Beldars and carted in by Contractors at a rate of 9 Rupees per 100 maunds. 800 Carts were constantly employed on this work alone during the season under review.

The two Government Hindostani Kilns yielded a return of 83½ per cent which was an excellent result, but the bricks were dear, in this system of burning, owing to the scarcity of the description of fuel (Khar and [illegible]) required, some of which had to be carted in from villages distant about 6 miles, and the carriage of fuel alone for the first [illegible] cost the sum of Rs 643. Oopla, which on the Jumna Canals was obtained at 2 Rs cost at Roorkee Rs 6.8.0 per 100 maunds.

The Hindostani Kilns established in neighbouring villages were also successful, having contributed to the Grand Total out turn for the season 26,51,260 pukka bricks.

In

In the early part of this season the Kutcha Bricks were moulded upon the bare ground, and were of very bad shape, leading not only to failures in burning, by the uncompact way in which they piled into kiln, which admitting passages for air, flame and heat, caused the fire to be rapidly expended without doing its proper duty; but also to extra expense in the Masonry built from them by the amount of chipping and dressing which they required before being laid in the work. To remedy this, pukka terraces, or Masonry platforms, with even surfaces, were introduced on all the Brickfields upon which the bricks were moulded, and in a short time our bricks were equal to the best table moulded bricks that could be turned out. Up to the 31st July, however, the cost of the Kutcha bricks was very high, having been [illegible] per Lakh. The detail of this expenditure is introduced here, in order that a comparison may be made with similar detail for future years, when the improvements made in the relative situations of the Tughars and Moulding terraces had reduced the price of Kutcha Bricks to a fair average rate.

1 Brick Moulder @ 7 Rs per month	7	..	..
3 Beldars excavating and carrying earth to the Tughars, a distance of about 300 feet @ 4 Rs per month	12	..	..
1 Beldar breaking clods and rough tempering the [illegible]	4	..	..
3 Beldars mixing and carrying the clay to the moulder @ 4 Rs per month	12	..	..
1/6th of a Beldar for ashes & water @ 4 Rs per "	..	10	8
1/4th of a Bullock drawing water [illegible] day	1	12	..
Establishment	..	8	..
Sundries Expense of bamboo hand barrows, [illegible] and [illegible], wear and tear of well [illegible] and well ropes, repairing brick moulds, stacking the bricks, and occasionally covering them with grass chuppers to protect them from the rain	1	..	..
Total Company's Rupees	38	14	8

[Each moulder and his attendants, as per above account, cost per month Rs 38.14.8, and each on an average turned out 1000 Bricks per diem, or per month 31,000
Deduct for 4 Sundays in a month 4,000
Balance, the number of Bricks made by 1 moulder 27,000

Then if 47000 Pukha Bricks 12"×6"×2½" cost Co's Rs 68.14.6, One Lakh will cost Co's Rs 143..15..9

It must be understood that in showing the result of each seasons operations, a period extending from about the middle of October to the end of the month of June following is embraced. By the statements which are given below of the work done on the several [illegible], it will be seen that during the season as represented, the Bricks from the [illegible] Hindostani [illegible] are never available until after the season in which they were burned [illegible] has passed. [illegible], therefore, the 2,80,946 Pukka Bricks stated in a former paragraph to have been derived from Hindostani Kilns are not included in the returns, but are brought to account in the abstracts, for the [illegible] season.

The results of the season of 1847/48 may be described thus.

Pukka Bricks moulded		207,79,187
Burned in Kilns	164,99,139	
Used in [illegible]	8,35,001	
Destroyed [illegible]	25,73,133	
[illegible] remaining at close of season	8,70,915	
		207,79,187

The Produce from the Kilns so burned, was

Pukka Bricks [illegible] size	108,91,961	66 p. cent	on the number of Bricks [illegible]
Pilla — Do. — Do.	54,56,933	33 "	
[illegible]	1,19,615	1 "	

The total Cost of the seasons operations was

Co.'s Company's Rupees 16807..12..5

and in [illegible] [illegible] from this the value of the [illegible] Bricks made for the special purposes of pillars, [illegible] &c, and including altogether 32,55,286 Pilla Bricks which, as not being at the time required on the works, were held to be of no value, the following rates were [illegible] to the Bricks in ordinary use.

Pukka Bricks 12. 6. 2½ [illegible]	Co Rs. 115.4	5 [illegible]
Pilla — Do — Do — Do —	" — 250	[illegible]
[illegible]	" — 2	[illegible] 100 [illegible]

Sheet No. 9

PLAN

of

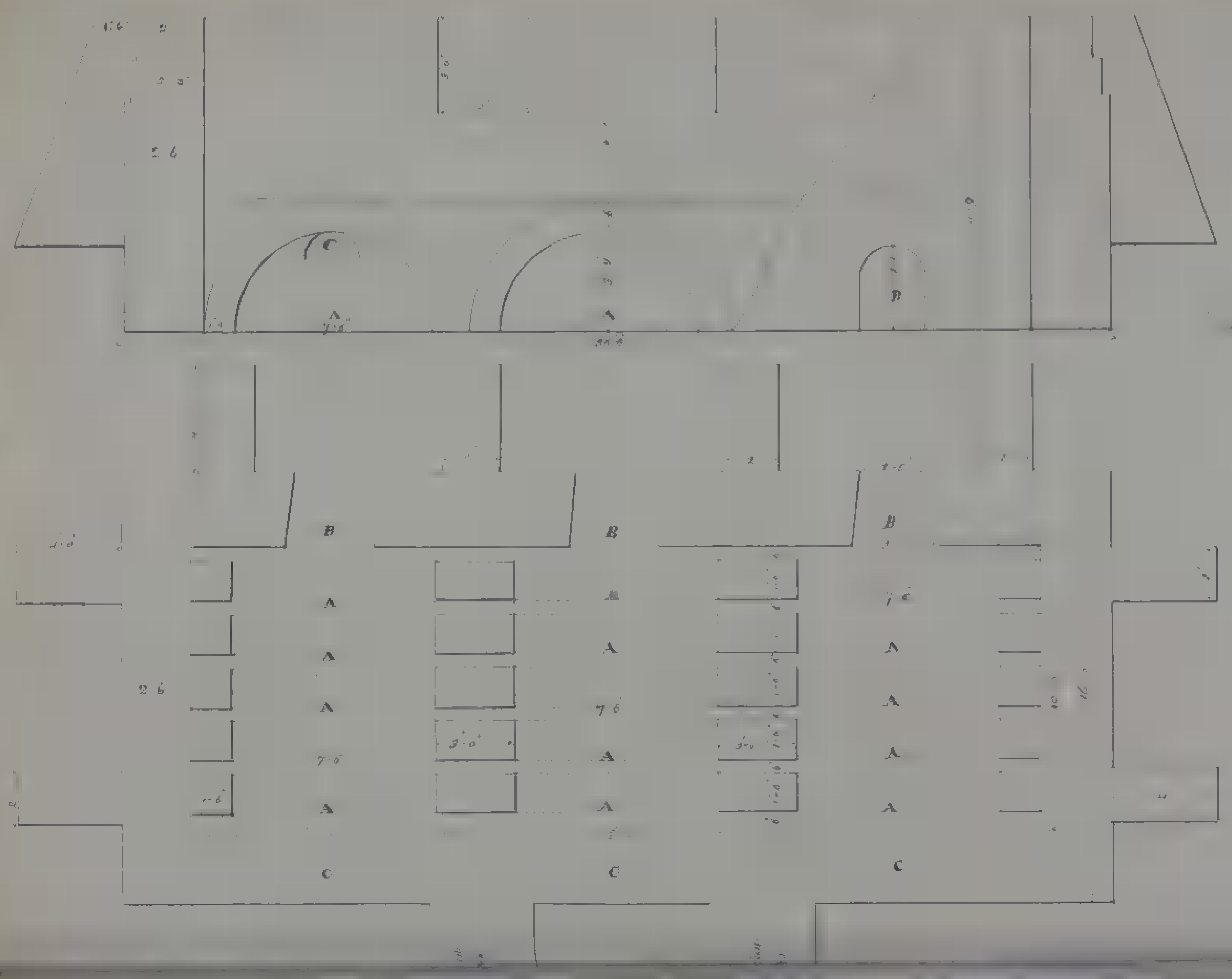
FLAME KILN

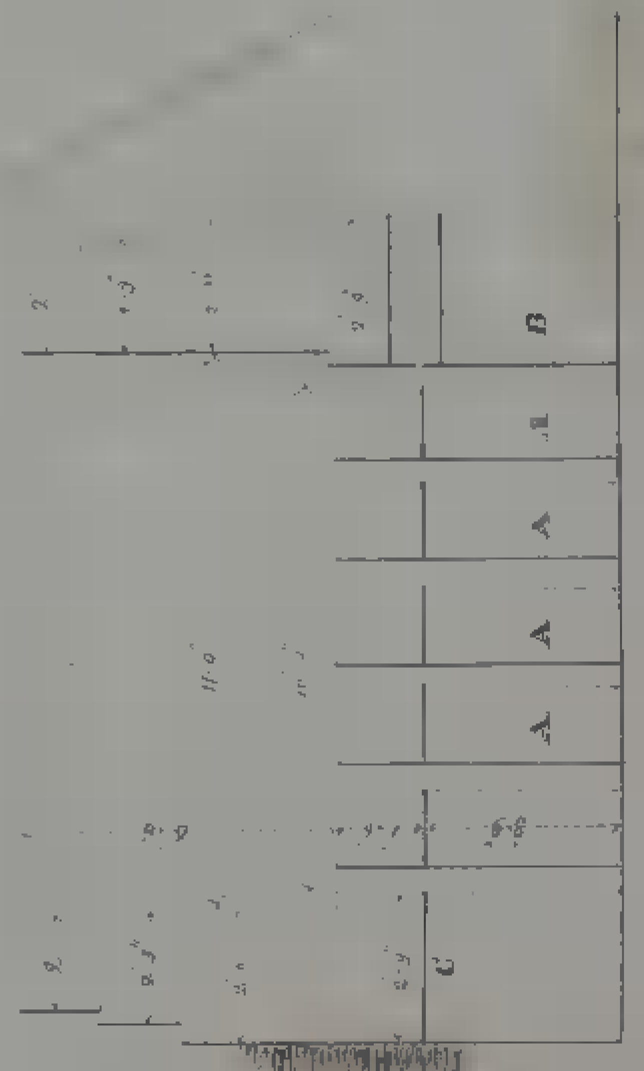
Reference

A Interior Vaults

B Exterior Flues for Firing Kilns

C Draft Openings in rear of Kilns used at Roorkee





Scale of 5 feet to an inch

The results of the season of 1847-48 had so fully proved the success of the "Bourn Flame" and "Roorkee" new system kilns over all others that had been tried, that the brick burning of 1848-49 was, for some time, confined to these two modes and more Flame kilns were carried on steadily; the outturn of Pukka Bricks increased in number, and each Quarter's accounts exhibited a reduction in their cost. In February 1849, Captain Weller of the Engineers visited Roorkee and spoke highly of a Flame kiln which he had used in Scinde. As we had already found the value of Flame kilns in their easy management and freedom from broken bricks, this plan was at once tried. The two first trials were not very successful, but in a short time, with some modifications introduced by Mr. Finn, it proved so satisfactory and economical in its results, that it was introduced to the exclusion of all others, not only in the Roorkee and Muhumdpur fields which were remodelled for the purpose, but in the new fields which were now being established at Dhunowree and Solimpoor. Plan and sections of this kiln are given in Plate No. 9, and the following Memorandum on the method of filling and firing it, which was submitted by Mr. Finn on the 1st March 1850, after a full year's experience had established its complete success, will be found of the greatest value.

"Memorandum on the Filling and Firing of Flame Kilns."

"Interior dimensions of Flame kilns in general use at Roorkee Kilns.

Length	31' " 6"
Breadth	11 " 6 inside flues
Height	6 " 6 — do —

Excavate to a depth of 3 feet for the floors or bottoms of the Kiln, giving any foundation below that depth, and

[illegible]

[illegible] as may require, to be away the ground in front of firing flues so as to allow the firemen ready access to them.

A Kiln is loaded in	1 day
Fired in	2 days
Cooled in	1½ days
Emptied in	1½ day
Total	6 days

A Kiln of the above given dimensions contains about 16000 Roorkee Bricks, each brick being 12" x 6" x 2½".

24 Coolies load a Kiln
18 do. unload do.; These men also assist in the brick presses First, Second, and [illegible].

The Quantity of Dry wood expended at Roorkee in firing a kiln 48 hours is 850 maunds; and the number of Beldars (Firemen) employed to feed the fires 24; thus, 2 men to each Flue of a Kiln. The firemen work in spells of 12 hours night and day, then for 48 hours being 4 spells, and 6 men for each = 24 men.

No Ashes or Earthing of any sort to be placed on the top of the Bricks in the kiln, and when the firing of the kiln is completed, the flues should not be closed up but left open.

Bricks and wood are placed separately in these kilns, the former are packed on top of the cross longitudinal walls, the bricks on edge, and the latter is placed in the 3 vaults at the bottom of the kilns. The spaces between walls, adjacent to longitudinal walls, are thus, to the admission of the heated air upwards. The lower tier of Bricks in kiln are placed about 2 inches apart, the 2nd, 3rd, 4th and 5th a little closer, and from the 6th to the 12th tier inclusive the bricks are packed in contact. When the bricks are placed in the kiln, the vaults are filled with wood and the firing commenced, the operation of which is carried on vigorously for atleast 24 hours, by which time, if the bricks are baked, the fire will be well up all over the top of the kiln.

During the cold season, or when bricks are not thoroughly dry on being packed into kiln, it requires fully 48 hours to bake them.

The wood issued to the Roorkee kilns is bought at the rate of 11 Rupees per 100 maunds. This wood is of various sorts, but by far the greater part of it is Dhak which is supposed to be about the very best description that could be used for the purpose. Babool, Kikar and Tamarind are all good and doubtless

[illegible] of either sort, a much less quantity than we expend of Dhak would suffice to bake a [illegible] of bricks — but of these we have none here.

"Firing kilns on high windy days should if possible be avoided, for then the bricks require a longer time to bake, and the kilns seldom or never afford a good return, the bricks [illegible] side invariably remain unbaked.

"The average return of Pukka from nutcha bricks baked in the Flame kilns at Roorkee in the month was 81¾ per cent. Some of the kilns have even yielded a return of 92·8 per cent".

[illegible]

At the commencement of this season (October 1848) Hall's brick making machine (for a description and plans of which see appendix) was set up at Roorkee. Mr [illegible], and the overseer Sergeant [illegible], in immediate charge of the Roorkee Brick fields, first made themselves acquainted with the working of the machine, and then taught a party of Beldars to use it. For the first 3 months, owing, probably to the [illegible] [illegible] of the [illegible] employed, it was constantly getting out of order, and considerable interruption to progress was the consequence; but Mr [illegible] persevered, and before the close of the season, had the satisfaction of seeing it work regularly and [illegible] 11,641 Bricks made [illegible] day are [illegible] fully equal to the best that can be obtained in England or America. These Bricks, from the process the clay undergoes in its passage through the pug-mill, are [illegible] [illegible] and when burned are found to be very close grained; their only disadvantage being, that their size 6½" × 4½" × 3" differs from that in common use on the Ganges Canal works. They were invariably burned in Bundela [illegible] under the supervision of the Government Establishments.

Before this machine was in full work, the men employed on the Ganges Canal brick fields as moulders were the most [illegible] [illegible]

-tractable and troublesome class of people that were on the works, their combined and frequent efforts to evade the doing of a fair day's work, at the then higher rates of pay, caused much anxiety; [illegible] attempts to [illegible] a moulder, [illegible] was found with the quality or quantity of [illegible] required by the [illegible] [illegible] the [illegible] of the whole body. [illegible], they saw that we could turn out from the machine 11000 Bricks per day, independently of themselves, [illegible] the [illegible] double of our people, and [illegible] they were glad to [illegible] to [illegible] a full day's work.

At first it was attempted to work the machine by horses, but they were found not [illegible] as bullocks, and [illegible] of these latter animals were, therefore, employed daily in [illegible] and driving the Clay in the Pug mill. They worked from dawn till noon, and [illegible] from 2 P.M. till dusk.

At the close of the season, the complement of men attached to the machine for working was as follows:

Excavating the clay and conveying it to the Pug mill, at an average distance of 130 feet	11 Beldars
Supplying the Cistern with water and cleaning up the drying ground	2 do
Filling the Clay cart from the outlets of the cistern	3 do
[illegible], and handing the moulds preparatory to [illegible] the clay into the machine	1 do
[illegible] the machine with empty brick moulds	1 do
[illegible] pressing the [illegible] into the moulds	1 do
[illegible] taking out the moulds	1 do
[illegible] the [illegible] taking off of the [illegible] and raising the moulds to the heads of the carriers	1 do
Carrying the loaded moulds from the machine to the drying ground	[illegible] do
[illegible] the bricks out of the moulds and placing the Bricks in regular rows on the drying ground	1 do
Total	28 Beldars

The following abstract of work performed, [illegible] number and cost of the Bricks made by

by this machine, from its setting up to the termination of the season, may well find a place in this report as it shews how progressively Mr Finn increased the turnout of Bricks, and decreased their cost.

Month	Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Bricks made daily	Remarks	Total monthly Expenditure, and rate of Bricks manufactured
October 1858	23			1	2		2090	[illegible]	Labour 13.12.11; Sundries 10.11; Total cost £20.7.9; Average cost per 1000 … 1.6
	24	9	.	1	2	.	2690		
	25	15	.	1	2	.	2400	[illegible]	
	26	9	.	1	.	.			
	27	.	.	1	.	.	.	Sunday	
	28	5	.	1	.	.	.		
	29	5	.	1	.	.	.		
	30	15	.	1	2	.	3011	[illegible]	
	31	21	.	1	2	.	2600		
Total		79	.	9	10	.	15,795		
November 1858	1	2	18	1	2	.	5590		Labour … 13.1 …; Sundries … 3.5; Total cost … 103.9.2; Average cost per 1000 … 1.11.9
	2	2	19	1	2	.	2130	[illegible]	
	4	.	7	1	.	.	.		
	5	.	7	1	.	.	.	Sunday	
	18	.	12	1			.	[illegible]	
	19	.	12	1			.	Sunday	
	20	.	18	1	2	.	4000		
	21	3	18	1	2	.	5790		
	22	3	16	1	2	4	6451		
	23	3	17	1	2	4	6350		
	24	3	23	1	2	4	6240		
	25	5	23	1	2	4	6570		
	26	5	23	1	.	.	.	Sunday	
	27	5	22	1	2	4	6550		
	28	6	22	1	2	4	6880		
	29	6	22	1	2	4	7000		
	30	3	23	1	2	4	7210		
Total		52	307	17	24	32	65,46[illegible]		
December 1858	4	5	24	1	2	4	3000		Labour … 17.9.3; Sundries … 0.0.0; Total cost 17.9.3; … 122.10.4; … 101.3.10
	9	3	22	1	2	4	4090		
	10	3	22	1	.	.		Sunday	
	12	3	24	1	2	2	6001	[illegible]	
Total		11	93	4	6	10	15,171		
January 1859	9	10	.	.	.	.		[illegible]	Labour … 71.3.2; Sundries … 1.14.2; Total cost 73.3.4; Average cost per 1000 … 11.4; … 71.14.9
	10	3	.	.	.	.		[illegible] for work	
	11	28	.	1	.	4	[illegible]		
	12	28	.	1	.	4	7370		
	13	28	.	1	.	4	7500		
	14	28	.	1	.	4	.	Sunday	
	15	15	.	1	.	2	3050	[illegible]	
	18	28	.	1	.	5	7000		
	19	25	.	1	.	4	7100		
	20	26	.	1	.	4	7000		
	21	26	.	1	.	.	.	Sunday	
	22	26	.	1	.	4	7000	[illegible]	
	26	29	.	1	.	4	7100		
	27	29	.	1	.	4	7400		
	28	29	.	1	.	.	.	Sunday	
	29	28	.	1	.	4	7500		
	30	29	.	1	.	4	7650		
	31	29	.	1	.	4	7500		
Total		[illegible]	.	16	.	48	86,290		

Month	Date	Total Men employed per month	Hours worked per Day	Bricks made Daily	Remarks	Total monthly Expenditure and rates of 1000 Bricks manufactured
January 1869	1	20	4	7700		Coolie Wages 37.10.9
	2	20	4	7150		Sundries 2.13.3
	3	20	4	8040		Total Rupees 40.0.0
	4	20		-	Sunday	Average total per 1000 Bricks 88.6.9
	5	20	4	8010		Do after deducting wages for Sunday 79.1.3
	6	20	4	8020		
	7	[illegible]			Clearing out the Kiln	
	8	20	4	6?10	& burning Bricks	
Total		143	24	45?10		
March 1869	20	1?			Filling kiln with Clay [illegible] & preparing	Coolie Wages 33.10.7
	21	19	4	8200		Sundries 2.3.8
	22	19	4	8100		Total Rupees 35.14.3
	23	19	4	8050		Average cost per 1000 Bricks 5.2
	24	19	4	8110		Do after deducting wages for Sunday 4.10.6.8
	25	19		-	Sunday	
	26	19	4	7120		
	27	19	4	6010		
	28	19	4	[illegible]		
	29	19	4	[illegible]		
	30	19	4	[illegible]		
	31	19	4	[illegible]		
Total		207	40	[illegible]		
April 1869	1	28		-	Sunday	Coolie Wages 136.[illegible]
	2	28	4	10??0		Sundries 6.12
	3	28	4	[illegible]		Total Rupees 1[illegible].1.3
	4	28	4	10[illegible]50		Average cost per 1000 Bricks [illegible]
	5	28	4	10[illegible]		Do after deducting wages for Sunday 6.8
	6	28	4	9[illegible]		
	7	28	4	10[illegible]		
	8	28		-	Sunday	
	9	28	4	10000		
	10	28		-	[illegible]	
	11					
	12	28	4	9?80		
	13	28	4	10180		
	14	28	4	10030		
	15	28		-	Sunday	
	16	28	4	10500		
	17	28	4	[illegible]		
	18	28	4	10370		
	19	28			Raining [illegible]	
	20	28	4	[illegible]		
	21	28	4	10380		
	22	28			Sunday	
	23	28	4	10000		
	24	28	4	9840		
	25	28	4	10?50		
	26	28	4	10?00		
	27	28	4	[illegible]		
	28	28	4	10300		
	29	28		-	Sunday	
	30	28	4	10100		
Total		734	52	218[illegible]		
May 1869	1	28	4	10500		
	2	28	4	10240		
	3	28	4	10500		
	4	28	4	10300		
	5	28	4	10000		
	6	28		-	Sunday	
	7	28	4	10840		
	8	28	4	10750		
[illegible]		224	28	73130		

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Month	Date	Builders employed per month	Builders [illegible] per diem	Bricks made daily	Remarks	Total monthly Expenditure and rates of the Bricks manufactured
Brought on		224	28	73430		
May 18[illegible]	9	28	4	10520		[illegible]
	10	28	4	10650		
	11	28	4	10560		
	12	28	4	10700		
	13	28	"	"	Sunday	
	14	28	4	10680		
	15	28	4	10680		
	16	28	4	10650		
	17	28	4	10700		
	18	28	4	10850		
	19	28	4	10550		
	20	28	"	"	Sunday	
	21	28	4	10460		
	22	28	4	10500		
	23	28	4	10900		
	24	28	4	10800		
	25	28	4	10950		
	26	28	4	10900		
	27	28	"	"	Sunday	
	28	28	4	10900		
	29	28	4	10900		
	30	28	4	10950		
	31	28	4	10930		
Total		868	108	267410		
June 18[illegible]	1	28	4	10900		[illegible]
	2	28	4	10950		
	3	28	"	"	Sunday	
	4	28	4	10900		
	5	28	4	10930		
	6	28	4	10900		
	7	28	4	10950		
	8	28	4	10650		
	9	28	4	10630		
	10	28	"	"	Sunday	
	11	28	4	10960		
	12	28	4	10800		
	13	28	4	11[illegible]		
	14	28	4	11000		
	15	28	4	11300		
	16	28	4	11450		
	17	28	"	"	Sunday	
Total		476	56	134850		

* 1[illegible] [illegible]

Total Number of Bricks made by this [illegible] during the [illegible] Season [illegible] at an average cost of [illegible] 8. 9. 8 [illegible].

Bricks made by the [illegible] during the month of May cost on an average [illegible] [illegible] the rate of the Bricks moulded by hand on the [illegible] at [illegible] during the same Month was [illegible] 91. 0. 10 [illegible] the pay of the [illegible] days for Sundays [illegible] cases

[illegible]

[illegible] [illegible], viz. the last [illegible] Brick (moulded) $11\frac{1}{2} \times 4\frac{1}{4} \times 2\frac{5}{8}$ [illegible] 28 Moulders at [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] made with [illegible] machines on an average 11000 bricks per day, [illegible] during the same period to make 11200 [illegible] moulded bricks if required.

Moulders @ 6 Rs per month – 144

Mouldars @ 4 – Do – 36

Total – 53 [illegible]

One of Clayton's Brick making machines [illegible] [illegible] during this season, but too late to [illegible] [illegible] [illegible] [illegible].

Kundastan Kilns were as usual estab-lished at outlying [illegible] and their out turn [illegible] [illegible] at the close of the season the results [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The [illegible] of [illegible] [illegible] made [illegible] [illegible] [illegible] [illegible] [illegible] Rs 110. 0. 0 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

1 Mason [illegible] 6 [illegible] [illegible]	6	[illegible]	[illegible]
3 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]	12	[illegible]	[illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]	10	[illegible]	[illegible]
[illegible] [illegible] [illegible] [illegible]	[illegible]	10	8
[illegible] [illegible] [illegible]	1	12	[illegible]
[illegible]	[illegible]	8	[illegible]
[illegible] [illegible] [illegible]	1	[illegible]	[illegible]
[illegible] [illegible] Rupees	32	2	8

[illegible] [illegible] [illegible] [illegible] [illegible] of 2,700 Bricks is [illegible] [illegible]

[illegible] of 2,700 cost Rs 32. 2. 8. [illegible] [illegible] [illegible] Rs 119. 0. 0

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] season		11,053,[illegible]
[illegible] [illegible]	[illegible]	
[illegible] [illegible] [illegible] [illegible]	302,152	
[illegible] [illegible] [illegible] [illegible]	[illegible] 13 [illegible]	
[illegible] [illegible] [illegible] [illegible]	53 [illegible]	[illegible] 23,6[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] Bricks		[illegible] 328	[illegible]	[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible]	Do	30,03[illegible]	25[illegible]	
[illegible]	[illegible]	1,3[illegible]	[illegible]	

The produce of the [illegible] kilns was 36,02,[illegible] Pukka Bricks, making the total results of the season as follows.

Pukka Bricks		47,00,157
Peela Do		3608-20
Jhama	Cubic Feet	130[illegible]26

The total cost of the seasons operations was

Company's Rupees 1,49,219.0.11

giving, under the same conditions as explained in the seasons resumé, the following average rates for the bricks in ordinary use.

Pukka Bricks 12×6×3 [illegible]	Rs As Ps	36 . 2 . [illegible]	per Lakh
Peela Bricks Do		2.50 . [illegible]	Do
Jhama		3 . 0 . [illegible]	per 100 cubic feet

1849-50.

The Brick-making Season of 1849-50 commenced at Roorkee and [illegible] in October 1849. The [illegible] established during the season at Dhunowree(?) and [illegible] [illegible] progress [illegible] February 1850. [illegible] provided with [illegible] [illegible] [illegible] bricks [illegible] [illegible] [illegible] burning the bricks [illegible] [illegible]. [illegible] a brick making machine on the [illegible] [illegible] [illegible] manufactured in the [illegible] workshops was set up at [illegible] and [illegible] [illegible] [illegible] success as that [illegible] [illegible] brought [illegible] from England. By the end of the season [illegible] [illegible] [illegible] made from [illegible] [illegible] [illegible] at Roorkee, [illegible] [illegible] at [illegible], [illegible] [illegible] [illegible] [illegible] in which the whole of the [illegible] operations were carried on.

[illegible] Brick-making [illegible] although [illegible] [illegible] was made [illegible]

of use proved an entire failure on our Works, and was eventually abandoned.

Hall's Brick making machine continued to keep up its character, and the maximum out turn in any one day during the season was 13,000.

The same course of work was gone through as described for 1848-49, and the results show a considerable improvement.

The average cost of the Kutcha Bricks made on the Government Fields was Rs. 88.4.3 per lakh. The detail of this rate is represented in the following table.

1 moonshee	6 Rs. per month	6	
1 Bildar Superintending in carrying out the work, breaking clods, rough tempering &c.	4 Rs. per month	4	
2½ Bildars digging and carrying the prepared Earth to the moulders	4 Rs. per month	10	
2½ of a Bildar to cessation and Labour [illegible]			10 3
[illegible] of a Bullock drawing water	[illegible]	1	12
Moulders [illegible]			6 6
[illegible]	Details as in former table	1	0
Cost of 1,00,000 Bricks — Company's Rupees		23	13 2

Cost of 1,000 was Rs. 23.13.2 — Lakh will cost (88) [illegible] 88.4.3.

The present season exhibits the Kutcha Brick making in its most favorable aspect, the arrangements made and the system we arrived at the [illegible] were now matured. The quantity of work that could be done by each individual employed was known, and the performance of it strictly insisted on, and no [illegible] one found no variation, except in the one item of "Coolie [illegible] and carrying Earth [illegible]" was permitted. This item was necessarily fluctuating, and it was entirely dependent on the distance the Earth had to be carried. The Excavation of this Earth was carried on within a [illegible] [illegible] of the centre of our Operations and [illegible] a [illegible] distance may be formed for

for the convenience of the Government [illegible] has been, the reservoir was 1100 feet long, 370 feet broad and 12 feet deep.

The number of Burnt Bricks [illegible] made in the Government kilns was, including those on hand at the close of the previous season		256,13,771
Filled into Kilns	166,48,000	
Used in [illegible] Kilns	23,95,350	
Loss by Rain, Wastage, &c.	65,70,421	256,13,771

The outturn from those filled into kilns was:

Pukka Bricks		1[illegible],33,540	79 per cent	On the whole Bricks filled into kilns.
Pila do.		39,75,200	18 per "	
Jhama	Cubic feet	79,291	3 per "	

The portion of the unburnt kilns was 4,40,000 Pukka Bricks, making the total outturn of the season as follows:

Pukka Bricks		10[illegible],33,540
Pila do.		39,75,200
Jhama	Cubic feet	79,291

Hand Brick [illegible] made during the season 15,15,663 unburnt Bricks, of which 14,33,663 were piled into kilns, and [illegible]1,000 were destroyed by rain.

The total cost of the season's operations was

[illegible] 01.6.5

Taking into consideration [illegible] the average rates of the Bricks [illegible] ordinary [illegible]:

Pukka Bricks	12"×6"×2½"	[illegible]	752	12	4	per lakh
Do. do.	9½"×4½"×3"	"	536	..	..	do.
Pila do.	12"×6"×2½"	"	250	..	..	do.
Jhama			6	..	..	per 100 Cubic feet

About 1500 Carts were constantly employed during the season in Carting [illegible] wood to the several Kilns.

[illegible]

[illegible]

[illegible] 3,00,000 [illegible] was paid [illegible] P. 500.

[illegible]

[illegible] was —		304,52,045
[illegible] —	221,11,100	
[illegible] —	30,66,115	
[illegible] —	57,44,830	304,52,045

[illegible] was

[illegible] —	186,42,100	550 [illegible]	[illegible]
[illegible] —	25,57,800	114 "	
[illegible] —	66,546	3 "	

[illegible] 7,00,000 [illegible] Bricks, [illegible] as follows:-

[illegible] —	204,42,100
[illegible] —	25,57,800
[illegible] —	66,546

The

The total cost of the outturn of produce was

Company's Rupees 219580.5.9

giving under the conditions before explained, the following average rates for the Bricks in ordinary use,

Pukka Bricks	12 x 6 x 2½	Co.'s Rs	763.7.0	per Lakh
Do.	do. 9½ x 4½ x 3	"	536 "	do.
Kucha	do. 12 x 6 x 2½	"	230 "	do.
Jhama			6	per 1000 cubic feet

The maximum number of hands employed in moulding & removing the bricks was 1500 per day.

1851-52

Hand brick making machines turned out during this season 54,23,000 kutcha Bricks the whole of which were piled into the Hindustani kilns in which they were baked. Its maximum rate of turning was equal to 13500 kutcha Bricks per diem.

Kutcha Bricks moulded on the terraces at the commencement at a cost of an average Company's Rupees 3.13.4 per lakh.

The number of kutcha Bricks moulded on the commencement terraces —		409,74,500
Filled into kilns	313,35,400	
Used in repairs &c.	52,26,800	
Loss by rain, wastage &c.	44,17,300	409,74,500

The return from those filled into kilns was

Pukka Bricks	257,81,100	83 per cent
Kucha do.	38,65,300	13 per cent
Jhama	cubic feet 2,57,800	4 per cent

[illegible]

The return from the Hindustani kilns was

Pukka

was [illegible] 3,00,000 Pukka Bricks, making the total results of the season as follows:—

Pukka Bricks	350,81,120
Tile [illegible] do.	38,65,300
[illegible]	37,820

The total cost of the Season's operations was

Co.'s [illegible] Rupees 305013 . 3 . 1

[illegible] the usual [illegible] [illegible] rates of the Bricks in ordinary use.

Pukka Bricks [illegible]	[illegible] 604	15 8	per [illegible]
do. do. [illegible]	536		do.
Tile do.	550		do.
[illegible]	6		per 1000 [illegible]

The maximum number of [illegible] [illegible] per [illegible] day during this Season in the [illegible] [illegible] to the [illegible] was 2000.

1852-53.

[illegible] Brick making machines [illegible] out during this season [illegible] 3,400 [illegible] Bricks [illegible] [illegible] [illegible] [illegible] The maximum [illegible] by these machines was at the rate of 12,000 Bricks per day each.

[illegible] Bricks moulded on the [illegible] of the Government [illegible] [illegible] [illegible] 90 7 9 per Lakh.

The [illegible] [illegible] of Bricks moulded on the Government [illegible] was:—		[illegible]
[illegible]	316,91,060	
[illegible]	59,44,240	
[illegible]	54,69,912	4[illegible]

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The return from the [illegible] Kilns was

Pukka Bricks	[illegible],43,800 @ 8 per [illegible]	(On the [illegible] Bricks [illegible])
Pila do	36,73,700 12 per [illegible]	
Kilama	36,035 6 per [illegible]	

The produce of the Hindostani Kilns was 90,00,000 Pukka Bricks making the total for the season as follows:—

Pukka Bricks	35[illegible],43,800
Pila do	36,73,700
Kilama	36,035

The total cost of the season's operations was:—

Company's Rupees 3,50,500.14.4

Making on the usual conditions the following average rates for the Bricks & Kilama viz:—

Pukka Bricks 12"x6x2½	Rupees	940	14.0 per	Lakh
Do Do 9"x4½x3	"	650	" "	do
Pila Do 12"x6x2½	"	250	" "	do
Kilama	"	6	" "	per 100 cubic feet

The great increase over last year in the cost of the Pukka Bricks is entirely owing to the increased price that had to be given for the carriage of the wood which had necessarily to be brought from a greater distance as the Jungle nearer to our Kilns became exhausted.—

1853-54

[illegible] for [illegible] at [illegible] the close of 1852 [illegible] [illegible] been [illegible] [illegible] [illegible] [illegible] most [illegible] to the [illegible]

[illegible]

[illegible] [illegible], [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] had been taken
by the Executive Engineer to prepare the
Aqueduct [illegible], [illegible] [illegible] [illegible] of [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
was also [illegible] [illegible]; and that [illegible]
[illegible] [illegible] was [illegible] on the 31st January
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] complete
the [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] 22.36.500 Kutcha Bricks
21.63.500 of [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible], [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] contained
[illegible] 14000* [illegible] [illegible] [illegible] [illegible] [illegible]

Kutcha Bricks [illegible] [illegible] [illegible] the
[illegible] [illegible] [illegible] [illegible] [illegible], [illegible]
[illegible] [illegible] 369.13.0 [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] up to the 31st [illegible] [illegible] was; —		2,07.43.280
[illegible] [illegible]	2,12,96000	
[illegible] [illegible] [illegible]	36,65200	
[illegible] [illegible] [illegible] [illegible]	3.29880	
[illegible] [illegible]	14,52,200	2,07.43.280

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible], [illegible] [illegible] [illegible] [illegible]

[illegible] Kutcha Bricks	178,80,613 [illegible]	On the Kutcha Bricks [illegible] [illegible] [illegible]
[illegible] [illegible] Do	2079100 [illegible]	
[illegible] [illegible] [illegible] [illegible]	72923 [illegible]	

The [illegible] [illegible] contributed
[illegible] the supply of 7500,000 Kutcha Bricks
[illegible] [illegible] the total [illegible] that [illegible] [illegible]
[illegible] [illegible] were available for the works up to

* Note. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Bricks [illegible] [illegible] [illegible] [illegible]

in [illegible] of the [illegible] [illegible] by [illegible] as follows:-

Pukka Bricks	2,53,30,613
Puta do	20,79,100
Drains [illegible]	1,092

The total [illegible] of the Operations during this period was

(Rs. 1,36,342.13.1)

[illegible] (under the usual conditions) the following rates for the Bricks [illegible]

Pukka Bricks	12 x 6 x 2½	Rs. 1,30 [illegible]	[illegible]
Do	9 x 4½ x 3	6,50	do
Puta Do	12 x 6 x 2½	4,50	do
Drains		6	[illegible]

The following condensed Abstract of the [illegible] results will [illegible] the extent of the Brick making [illegible] in the Northern Division of [illegible] from the Commencement [illegible] to the 31st [illegible]

	Pukka Bricks [illegible]	Puta Bricks [illegible]
From Commencement to [illegible]	1,03,16,171	51,23,130
" [illegible] 1847 to [illegible] 184[illegible]	35,00,000	11,00,000
" [illegible] 1847 to [illegible] 1848	1,05,01,001	34,36,035
" [illegible] 1848 to do 1849	1,[illegible],00,157	36,0[illegible],[illegible]20
" [illegible] 1849 to do 1850	1,59,33,210	32,75,200
do 1850 to do 1851	[illegible],100	[illegible]5,300
do 1851 to do 1852	3,50,31,150	38,65,300
do 1852 to do 1853	3,52,43,800	36,73,700
do 1853 to 31st [illegible] 1854	2,53,30,613	20,79,100
Total	18,07,70,538	3,07,14,992
Grand Total	21,15,[illegible],530	

and a [illegible] idea of its [illegible]

may be given by stating that if the [illegible] [illegible] of [illegible] were laid lengthwise they would form a line upwards of 14000 miles in length.—

The memorandum appended to this paper was drawn up by Mr [illegible] for another purpose than this report, but it very appropriately takes its place here, and exhibits results during the whole of the period which it embraces, highly creditable to that [illegible] [illegible].

Memorandum of Operations of the Material Department, Northern Division, Ganges Canal, drawn up by Mr. James Finn, Executive Officer of Materials.

The purport of the figured Statement which accompanies this paper is to exhibit in a succinct yet comprehensive manner a summary of my principal doings as Executive Officer of Materials at Roorkee, and I shall here endeavour further to elucidate such points as appear to me to call for remark. I shall, however, confine myself in this memorandum as I have done in the figured Statement, to the staple articles of building materials supplied to the Executive Engineers viz. Bricks – Lime – and Soorkee, deeming it undesirable to hazard being tedious by entering on such comparatively insignificant items as Cattle, Timber, and Miscellaneous materials.

2 – The Number of Pukka Bricks [illegible] on the books of the Northern Division since the Material Department has been in my hands, together with those now in store, is as follows.

Season	Number
1847/48	[illegible]
1848/49	160,78,104
1849/50	216,71,221
1850/51	255,93,135
1851/52	338,[illegible],[illegible]71
1852/53	330,37,064
From 1st August 1853 to 31st March 1854	299,52,561
Total	1707,01,938

besides 200,68,040 Peela Bricks and 665,516 cubic feet of Jhama. Of the above 1116,91,39[illegible] Pukka Bricks were of the standard size 12"

12"×6"×2½" and were manufactured at an average rate of Rs 995.3.6 per Lakh including all expenses of Carriage and stacking. The demands on me for this material, it will be seen, were far beyond what was originally contemplated, but I am happy to say that on no occasion were the works stopped from the supply running out. I would invite attention to the column shewing the cost of manufacture of the Standard Bricks. The first season's work may be regarded as experimental; after which, notwithstanding the enormous sums expended, as preliminary† on Dead Stock, nearly all of which has now been written off, it will be seen that up to November 18[illegible] there was a steady and gradual reduction in rate which at this period reached the minimum of Rs 750, with Carriage &c. 1100 per Lakh, and in Round Kilns and under ordinary circumstances, I do not [illegible] they would [illegible] be cheaper at [illegible]. [illegible] there is again a rise in price, as [illegible] naturally be expected, owing to the greater distance which Firewood had to be brought. At the commencement of operations this distance was [illegible] miles, latterly it was [illegible] miles. The supply of fuel [illegible] has been [illegible] which [illegible] it has cost me from 10 to 15 Rupees per 100 maunds; and I have brought in and consumed the enormous quantity of 91,55,734 maunds, [illegible] away [illegible] from 80 to 100 [illegible] miles of Jungle!!

† Kilns Cost	27,400
Drains ..	24,654
Wells ..	3026
Total Rupees	55080

8. I [illegible] add that the whole of the Bricks made during the first season were raised in Large Kilns on the old [illegible] pattern. Towards the close of the [illegible] season, a few experimental [illegible] Kilns were tried, and with such favorable results that [illegible], they have been

was in full use, and the English was entire-ly discontinued.

4.- The Quantity of Lime furnished to our works is Maunds 1938,200 viz.

Period when Supplied			Quantity maunds srs
	Season of	1847/48	171,024 20
	Do	1848/49	312,233 ..
	Do	1849/50	214,315 12½
	Do	1850/51	269,149 30
	Do	1851/52	314,011 37½
	Do	1852/53	302,896 2½
Part of	Do	1853/54	306,148 32½
		Total maunds	1938,200 ..

issued at an average rate of Rs 26. 3. 0 per 100 maunds. The established rate of this material when I assumed charge was 30 Rupees per 100 maunds, and I was given to understand that even a higher price had been paid for it. As our work progressed and competition was promoted, I thought an opportunity offered for getting this article at a reduced rate, and to a certain extent I succeeded in the second season of our operations. In the following year, how-ever I proceeded too far. I paid no more than Rs 23. 12. 0 per 100 maunds; the con-sequence was that the supply fell off, the con-tractors would not come forward and I was reduced to the necessity of advancing the rate by Rs 1. 8. 0 per 100 maunds. It will be seen from the statement accompany-ing that since November 1850, the price of Lime has remained fixed at Rupees 25. 4. 0 per 100 maunds, and I be-lieve this to be a fair rate both for Con-tractors and Government.

5. The issues of [illegible] annually including stock now in hand have been:-

Season

Period when supplied	Quantity maunds	seers
Season of 1847/48	54,367	10
Do 1848/49	102,935	30
Do 1849/50	418,867	30
Do 1850/51	412,751	30
Do 1851/52	619,067	25
Do 1852/53	672,268	25
Season Do 1853/54	1130,896	13
Total maunds	3331,15[illegible]	5

at an average of Rs 14.9.0 per 100 maunds. The rate when I joined was Rs 11.12.0; it has been gradually [illegible] with the cost of Bricks; [illegible] paid it reduced to Rs [illegible] and then to Rs [illegible] per 100 maunds; and is at present [illegible] to Rs 13.3.0.

6. I have now very [illegible] in my extensive dealings with Contractors for Supplying made Bricks, [illegible] and Carriage of Stones. The Brick contractors I had [illegible] constant [illegible] about [illegible] Contractors. [illegible] as many as 400 Contractors with 2000 [illegible] from the [illegible]. [illegible] by very numerous Contractors was paid to them [illegible] and although I have been obliged to make large advances to get [illegible] to work, and to retain them afterwards, I [illegible] to this date lost One [illegible] by the Contractors for Bricks and [illegible]; and I do not lose about Rs 150 by the [illegible] Contractors [illegible] and [illegible] the Contracts were completed, and they [illegible] from circumstances that they [illegible] had then [illegible] behind them.

In conclusion, I would advert to the large sum of money which has passed through my hands for the supply of materials for the Northern Division and

Endeavour

endeavour to shew, that it has been, at [illegible] least, not unprofitably expended. The clear total of money laid out in making [illegible] [illegible] Establishment, [illegible] a [illegible] Expenses [illegible], as per accompanying Statement, Co's Rs 2,348,398 [illegible] being spread over 7½ [illegible] years [illegible] a [illegible] outlay of 3,13,107.10.3 [illegible] charges, [illegible] expenses [illegible] the [illegible] [illegible] that of the Old Establishment [illegible] Current expenses, [illegible] the same [illegible] [illegible] would [illegible] maintained [illegible] the Executive and [illegible] Departments [illegible] separated [illegible] as early as possible [illegible] [illegible] at the [illegible] by reduction of rates. The average [illegible] during my [illegible] [illegible] Co's Rs [illegible] per [illegible], may be assumed as the rate of manufacturing [illegible] [illegible] 13[illegible] [illegible] equivalent to a saving of [illegible] per [illegible], or on 1,010,[illegible] Bricks 12 × 6 × 2½ [illegible] [illegible] [illegible] Co's Rs 8.0 – 4.3.0 = 3.13.0 per 100 maunds [illegible] on the total supply [illegible] 7,303.4.6. And in respect to [illegible] the reduction [illegible] equal to Co's Rs 2.3.0 per 100 maunds [illegible] 3531,13 maunds [illegible] [illegible]3.10.0 – [illegible] [illegible]

Saving on Bricks	Co's Rs	10,203 [illegible]	
" Tiles	"	7,2[illegible]	
" [illegible]	"	7,[illegible]3.10	35,211.9.15
Deduct [illegible] for 6½ years @ Rs [illegible] per annum			39,000
[illegible]			13,11,9.15

which

[illegible] 17, 93 [illegible] 6.—

3. Whilst [illegible] the difficulty of obtaining [illegible] in large quantities at a [illegible] providing [illegible] for the [illegible] transport [illegible] animals [illegible] [illegible] natural [illegible] extending a scale as was indispensable [illegible] the [illegible] Division; and allow the single [illegible] [illegible] considering [illegible] that the [illegible] satisfactory.

(Sig.) [illegible]
[illegible]

Statement or Abstract of Cash received in [illegible] of [illegible], and of [illegible] of [illegible] to works, with Rates of Each.

Period	Cash advanced to Ex. Officers of materials	Pukka Bricks 12"×6"×2.5"	Pukka Bricks [illegible]	[illegible]	Tile brick	Chunam	Stone Lime	Soorkee	Firewood brought on works	Pukka Bricks 12"×6"×2.5" pr. Lakh	Stone Lime per 100 maunds	Soorkee per 100 maunds
30th April 1848	195395 [illegible]	60,30,090	..	2610950	[illegible]	11,3[illegible]	35315 25	7,066 30		* 1211 13 1	29 9 7	11 10 9
31st July	105,000	39,39,[illegible]	..	20,033	[illegible]	3[illegible]	37 03 35	[illegible],300 30	[illegible]	* 1300 6 3	30 ..	11 12
31st Octr.	52,000	41,3[illegible],366	..	15,020	10,30,3[illegible]	[illegible]	[illegible] 15	23,0[illegible] 25		* 11[illegible] 3	30 ..	11 12
31st January 1849	111,200	63,5[illegible]	..	503,015	[illegible]	[illegible]	102,[illegible]	30,60[illegible] 33		* 10[illegible] 15 10	30 ..	11 12
30th April	134,500	33,[illegible]			[illegible]	[illegible]	[illegible]	3[illegible]		800	30 ..	12 3
31st July	79,400	16,66,22[illegible]	1,000	4,000	[illegible]	[illegible]	71,03[illegible]	33 [illegible] 10	15[illegible]	800 ..	28	12 8
31st Octr.	11,700	37,01,300	13,3[illegible]	1[illegible]	[illegible]	[illegible]	13 30	[illegible] 10		800 ..	2[illegible]	12 8
31st January 1850	63,200	52,20,[illegible]	10[illegible]		1[illegible] 236	23,0[illegible]	[illegible]	10[illegible] 15		750	2[illegible] 12	12 ..
30th April	107,000	[illegible]	[illegible]		[illegible]	[illegible]	[illegible] 10	17[illegible] 10		750 ..	[illegible] 12	12 ..
31st July	80,000	[illegible]	3[illegible]		[illegible]	[illegible]	121,37[illegible]	10[illegible]	[illegible]	750 ..	[illegible] 12	12 ..
31st Octr.	44,500	36,[illegible]	1,[illegible]		[illegible]	[illegible]	36 15	3[illegible]		780 ..	[illegible] 12	12 ..
31st January 1851	75,000	[illegible]	[illegible]	120	[illegible]	[illegible]	[illegible]	5[illegible],30		750 ..	[illegible]	12 ..
30th April	108,000	65,[illegible]	[illegible]		[illegible]	[illegible]	11[illegible]	15[illegible] 35		750 ..	[illegible]	12 ..
31st July	72,000	[illegible]	3[illegible]		[illegible]	[illegible]	110,[illegible]	1[illegible]	1[illegible]	750 ..	[illegible]	12 ..
31st Octr.	37,000	31,[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible] 5		750 ..	[illegible]	12 ..
31st January 1852	111,000	96,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 15	278,550 10		750 ..	[illegible]	12 ..
30th April	160,000	106,[illegible]	[illegible] 15		[illegible]		10[illegible] 30	12[illegible] 35		750 ..	[illegible]	12 ..
31st July	107,000	63,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11 [illegible]	1[illegible] 10	[illegible]	750 ..	[illegible]	12 ..
31st Octr.	35,300	[illegible],38,83[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 21		850 ..	[illegible]	12 ..
31st January 1853	75,000	59,26,92[illegible]	[illegible]	[illegible]	11,[illegible],105	[illegible]	[illegible] 10	[illegible]		850 ..	[illegible]	12 ..
30th April	150,000	111,33,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		950 ..	[illegible]	12 ..
31st July	105,000	[illegible]	[illegible]	93,[illegible]	[illegible]	[illegible]	[illegible]	1,[illegible] 6	1[illegible]	950 ..	[illegible] 4	12 ..
31st Octr.	53,000	[illegible],18,51[illegible]	[illegible]	118,[illegible]	[illegible]	[illegible]	[illegible]	1,[illegible] 12		950 ..	[illegible]	13 3
31st January 1854	150,000	130,32,5[illegible]	[illegible]	20[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 6		950 ..	[illegible]	13 [illegible]
31st March	100,000	66,[illegible]	[illegible]	309,[illegible]	[illegible]	[illegible]	10[illegible]	[illegible] 35	[illegible]	950	[illegible] 4	13 [illegible]
	231,3,398 4 [illegible]	1030,[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	1,[illegible]	33[illegible] 13 5	[illegible]			
In Store about		50,00,000						1,[illegible]				
Total	2345398 [illegible]	1110,[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	10[illegible]	3[illegible] 13 5	[illegible]			

* [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] provisions of [illegible] in Bricks [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] of [illegible] 1200 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible]
[illegible] [illegible]

APPENDIX

B

REPORT OF A COMMITTEE

ASSEMBLED BY GENERAL ORDERS COMMANDER IN CHIEF.

DATED 16TH SEPTEMBER, 1845.

UNDER INSTRUCTIONS FROM THE RIGHT HONORABLE

THE GOVERNOR GENERAL OF INDIA IN COUNCIL.

President

MAJOR W. E. BAKER, ENGINEERS.

Members:

SURGEON T. E. DEMPSTER, HORSE ARTILLERY.

LIEUTENANT YULE, ENGINEERS.

AGRA:

WM. H. BAYCOCK, SECUNDRA ORPHAN PRESS.

1847

AGRA:

Wm. H. Haycock, Secundra Orphan Press.

1847.

REPORT OF A COMMITTEE ORDERED TO ASSEMBLE BY G. O. G. G.

Dated the 16th September, 1845.

EXTRACT FROM GENERAL ORDERS

"Under instructions from the Right Honorable the Governor General of India in Council, the undermentioned "Officers are directed to form themselves into a Committee to assemble at such places and on such dates as may be fixed "by the President, for the purpose of reporting on the causes of the unhealthiness which has existed at Kurnaul, and other "portions of the country along the line of the Delhi Canal;—the Committee will also report whether an injurious effect "on the health of the people of the Dooab is, or is not likely to be produced by the contemplated Ganges Canal."

PRESIDENT:

MAJOR W. E. BAKER, *Engineers.*

MEMBERS:

SURGEON T. E. DEMPSTER, *Horse Artillery.*

LIEUTENANT H. YULE, *Engineers.*

REPORT.

Roorkee,
3rd March, 1847.

The conduct of the investigation entrusted to our Committee, and detailed in the annexed General Order, involved the necessity of personally examining the districts irrigated by the existing canals, and such other localities as seemed best suited for a fair comparison with them. For this purpose, the Committee met at Kurnaul on the 30th November, 1845, and proceeding southward had made considerable progress in the examination of the irrigated districts west of the Jumna, when they were summoned to military duty with the army of the Sutlej. On the 1st November, 1846, the enquiry was resumed, and has continued without further interruption.

2nd. The route followed by our Committee may be traced on the accompanying sketch map. It was prescribed in some measure by the official engagements of Major Baker, whose inspection of the canals, &c. was necessarily performed in conjunction with his duties as a member of the Committee. It will be seen, that we have examined the irrigated and unirrigated districts on both banks of the Jumna, that we have visited the Nujufghur jheels, and have followed the proposed course of the Ganges canal for 83 miles, viz. from Hurdwar to the latitude of Meerut. In the course of this enquiry, we have travelled about 1400 miles. We have visited more than 300 inhabited localities, and have personally examined upwards of 12,000 individuals of all ages.

3rd. It was suggested by our medical member, and will be generally admitted, that a fair comparison of the sanatory condition of different districts must be founded on observations taken within a very brief period of each other, and under circumstances as nearly as possible similar. The observations taken in 1845 were, therefore, useless for our present purpose, and the necessity of completing our enquiry within a period

limited to about 3 months, compelled [redacted] to restrict our observations to the bodily condition of the people and to those more obvious circumstances which all modern authority concurs in pronouncing to be those most concerned in the production of disease.

4th. In the commencement of our investigation, we had hoped to derive much assistance from the results of enquiries conducted by our own native agents, and at our instance by the establishments of the Revenue and Canal departments. We have now before us [redacted] immense mass of reports obtained from such sources, but they are in general so vague and unsatisfactory, and are so little corroborated by our own personal observations, that we were unwilling to incur the labor involved in arranging and digesting them, with so little prospect of ultimately obtaining trustworthy results.

5th. Our principal object was to ascertain what relation subsisted between certain physical conditions of the different districts, and the liability of their inhabitants to miasmatic fevers. The former could be noted with some degree of certainty, but in the absence of official medical statistics, and with frequent reason to doubt the accuracy of oral testimony, although collected by ourselves, we could not obtain even an approximation to [redacted] fair comparison of the past and present sanatory condition of the inhabitants of different localities. In this difficulty, it was suggested by our medical member, that the condition of the spleen in any number of individuals would be a fair test of the probable frequency and degree in which they had suffered from malarious influences. Having satisfied ourselves of the propriety of this test, and finding it easy of application, we determined to adopt it, and have based [redacted] the results so obtained the most important of the conclusions at which we have arrived. In the Appendices B and C will be found a memoir by Mr. Dempster, stating the medical grounds for the adoption of this test, and describing the method followed in applying it.

6th. The present season, in which our observations were taken, has been a generally healthy one, and was preceded by [redacted] season scarcely less favorable. It is also separated by 8 or 9 years of good harvests from [redacted] season of drought, a circumstance decidedly in favor of unirrigating villages which have had abundant time to recover from any sickness that

might have been entailed upon them by the unmitigated hardships of famine.

7th. Amongst the instructions furnished for our guidance from the Adjutant General's office, we find [redacted] series of questions, [redacted] each of which His Honor the Lieutenant Governor, North Western Provinces, has called for our recorded opinion. These questions embrace nearly all the important points of our investigation, the results of which cannot perhaps be shewn in a more intelligible form than that of consecutive answers to His Honor's interrogatories, [redacted] follows :—

8*th*.—First. *How far is the unhealthiness which has prevailed of late years at Kurnaul, Delhie, Hansi, Hissar and Rohtuck and in the villages irrigated from the canal attributable to the existence of the canal, and to irrigation from it?*

Reply I.—We have obtained satisfactory proof that an extensive epidemic influence, in whatever it may have consisted, or however produced, undoubtedly pervaded a large portion of the North Western Provinces of late years, and especially during and after the rainy season of 1843. To this we would partly attribute the sickness which occurred in the canal irrigated districts, where, however, it is also certain, that the disease was generally, though not universally, more prevalent and severe than in other situations.

9*th*.—Second. *Did similar unhealthiness prevail at the same time in other parts of the country not irrigated from the canal and beyond the reach of its influence? If so, to what cause is that unhealthiness attributable? Was the type of disease in the two cases the same?*

Reply II.—Nearly all places within the North Western Provinces also suffered from fever at the same time, and in [redacted] degree greater than usual.* We have, moreover, every reason to believe, that in certain situations neither irrigated from the canal nor within reach of its influence (as at Kythul, in the vicinity of the Nujufghur jheels, and in the khadir of the Jumna, &c.), fevers prevailed to an extent and with an intensity, as great [redacted] in the worst of the canal villages. The season of the year at which the disease appeared, its symptoms, progress, and consequences, would mark it to have been every where of

* See Appendix D.

the [redacted] type, viz. the endemic (remittent and intermittent) of the rainy season, but every where, and especially in naturally malarious localities, greatly aggravated by the constitution or peculiarity of the season.

10*th*.—Third. *If you consider the canals to have been the cause of unhealthiness along their course, have you any grounds for thinking such to be the unavoidable result of canal irrigation,* [redacted] *is it attributable to other causes, such* [redacted] *intercepted drainage, flooding from canal, peculiarity of the soil irrigated, &c.?*

Reply III.—By far the greater part of the evils we have observed have not been the necessary and unavoidable results of canal irrigation. In all situations where mischief was prominently marked, the natural drainage of the country had been checked or interfered with, stiff and retentive soils saturated with water, and natural disadvantages of site enhanced by excess of moisture.

11*th*.—Fourth. *Can* [redacted] *suggest any means whereby the agricultural benefit of canal irrigation may be continued* [redacted] *the country* [redacted] *large while Military Cantonments* [redacted] *large towns may be saved from the risk of unhealthiness?*

Reply IV.—The effects of canal irrigation appear to be remarkably local, almost strictly [redacted]: three miles would probably be a safe distance; but if irrigation were prohibited within a circle of five miles radius round [redacted] large military station, its salubrity would not [redacted] our opinion be affected.

12*th*—Fifth. *Can you suggest any change in the lodging or mode of life of the agricultural population within reach of* [redacted] *nal irrigation which would render them less liable than at present to any unhealthy influence occasioned by the canals?*

Reply V.—We feel doubtful whether any suggestion proceeding from authority, as to mode of life, exposure, food, clothing and construction of houses, would be adopted and voluntarily practised by the agricultural population. The best and most efficient prophylactics of this class, naturally come with competence and ease, but much might be done to improve the salubrity of village sites, viz. to stop irrigation within 200 yards round all canal

villages, and to plant [redacted] double row of trees round the unirrigated space,—to deepen all good village tanks, and to keep them full of water all the year round,—to drain all shallow pools in or about villages, or to convert them into proper reservoirs of water—and, wherever it may be possible, to improve the drainage of village sites. It would be no hardship [redacted] a new canal to make such works an invariable condition of obtaining water for irrigation. Cleanliness [redacted] of much though not of such vital importance [redacted] the [redacted] above recommended; but we fear [redacted] rules on this subject could be generally enforced.

13*th.*—Sixth. *Looking to the circumstances of the eastern Jumna or Saharunpoor canal, do you find that the effect of the canal irrigation on the health of the inhabitants has been the same there* [redacted] *the west Jumna or Delhie canal? If not, how do you account for this difference* [redacted] *effect?*

Reply VI.—The eastern Jumna canal furnishes examples of some of the best and worst results of canal irrigation. In the north and south divisions, where the soil is light, [redacted] drainage perfect, and irrigation carried on chiefly by "Rajbuhas," we perceive all the blessings and scarcely any of the evils of a canal. But in the centre division, where the drainage of the country has been greatly obstructed, and the soil [redacted] generally more stiff and clayey, the effect on the health of the inhabitants has been the [redacted] in kind, and nearly in degree, as in the objectionable portions of the Delhie canals.

14*th.*—Seventh. *Do you suppose that the contemplated Ganges canal will* [redacted] *will not exercise an injurious effect on the health of the people of the Dooab, over the whole of which it* [redacted] *intended to extend its influence? If you* [redacted] *of opinion that it will,* [redacted] *you propose any remedy or palliatives which will not involve the entire*

Reply VII.—In the course of our enquiries [redacted] the existing canals, we have found salubrity to depend in a great measure [redacted] the nature of the soil and the efficiency of the surface drainage. In the districts which it is proposed to irrigate, the obvious geographical features of the country enable us to pronounce with some confidence, that an efficient drainage, if not every where existing, is at least generally attainable. On the proposed line of the canal from Roorkhee to Meerut, we observed the soil to be light and friable; but without an extended examination, we cannot pronounce what proportion

abandonment of the undertaking?

of the remaining districts of the Dooab is characterized by similar soil. It can scarcely be hoped, however, that in the whole length of the proposed canal and its branches, some localities will not be met with, naturally and irremediably unfavorable to irrigation, and in which disease analogous to that found on the existing canals may not be expected to develope itself. On the other hand, if attention to drainage be made [redacted] absolute condition of participation in the benefits of the canal, [redacted] improvement rather than a deterioration of the general salubrity, may, in many instances, follow the introduction of canal irrigation. On the whole, we consider ourselves warranted in anticipating, on the Ganges canal, a far less amount of contingent evil than has been experienced [redacted] those of the Jumna, which were originally constructed without reference to many important points which have been especially kept in view in projecting the present work. And more especially in drawing inferences from results on the Delhie canal, great allowances should be made for the natural disadvantages of the country through which it flows—when compared with the Dooab generally. It is [redacted] remarkable feature of the "bangur" land bordering the right bank of the Jumna, that its drainage flows from, instead of towards, that river. The slope of the country, which is to the south-west, amounts to 1 foot or [redacted] foot 6 inches per mile, and is not sufficient to prevent even [redacted] slight obstruction from interfering with the flow of water. In subordination to the general slope, there are minor undulations, the excess of slope in [redacted] part being compensated by the absolute want of it in another. In such cases, the drainage of the higher lands collects in the lower, and from the latter there is [redacted] efficient escape. This is exemplified on [redacted] large scale in the Nujufghur jheels, and to a less degree in many other localities. The Dooab, on the other hand, is intersected by deep depressions, sometimes with the character of valleys, sometimes of ravines. These, except in [redacted] few instances, receive and rapidly carry off the surplus water of the country.

15. With reference to the latter part of this question, we have prepared [redacted] memorandum of measures connected with the execution of the Ganges canal, which we would strongly urge upon the attention of Government. With the details of these measures, which are of a technical

nature, [redacted] have not encumbered this report, but they will be found in Appendix F.

16. In addition to the above replies, it is proper [redacted] state [redacted] opinion of the effects produced by canals on the population of the irrigated districts, [redacted] regards their enjoyment of life and physical efficiency as agricultural laborers. During the cold season of 1846-47, (a healthy year) no obvious bad effects were perceptible in the adult population. The men generally looked healthy, happy, and thriving. The autumn crops were all gathered in, and the spring crops sown. The villagers on the western Jumna canals are better clothed and housed, and have [redacted] appearance of wealth and comfort than those off the canal. In a few of the worst localities, the aspect of the children [redacted] decidedly sickly: they were puny and pot-bellied. It must further be borne in mind, that our observations were made at a favorable season, and that we not only refrained from calling for the sick, but systematically discouraged their being brought forward.

17th. In our examination of districts unconnected with the canals, we have included some in which well irrigation is habitually practised, and in which [redacted] have found the population in [redacted] slight degree more subject to malarious diseases than in the totally unirrigated districts. We would, however, hesitate in attributing this difference to the mere circumstance of irrigation. [redacted] may perhaps be as justly ascribed to the abundance of springs and limited depth of wells, which [redacted] essential conditions of extensive well irrigation.

18th. In endeavouring to account for the observed difference of salubrity between well and canal irrigation, we beg to point out [redacted] material differences in the circumstances under which they are severally practised. Well irrigation is chiefly resorted to during the healthy season of the year: the water obtained with labor, is used with economy, and the natural moisture of the soil is not increased by the water being transferred from [redacted] lower stratum to the surface. Canal irrigation, [redacted] the other hand, is practised throughout the year, being applied even during the rainy season to the cultivation of rice. The water being more easily obtained [redacted] more likely to be used in excess, and such portion of it as may be absorbed by the soil increases by so much its natural humidity. It

may be added that foreign alluvial matter is more likely to be held in suspension in canal water, than in that obtained from wells.

19th. The pecuniary advantages of canal irrigation both to Government and to the farmer, are, we believe, fully recognized, and are so well understood by the cultivators themselves that they would willingly take their chance of the contingent evils of irrigation, in order to secure its benefits. Of this, we saw abundant proof in the course of our investigation. It would, however, have been an important test of the national value of canal irrigation, could we have accurately ascertained its effects on the density of the population, and whether the augmented capacity of the soil for supporting life compensated for the increased activity of influences inimical to its duration. In the hope of determining this question, we obtained from the revenue authorities certain returns, of which an abstract will be found in Appendix G., and which shew a marked difference in favor of irrigated lands. It is, however, to be regretted that the census forming the basis of these returns was taken several years ago, and may therefore not be strictly applicable to the existing condition of the country.

20th. In the foregoing paragraphs, we have confined ourselves to general conclusions, fearing lest, by entering on the consideration of local details, we should extend our report to an inconvenient length. But our attention having been particularly called to the station of Kurnaul, we beg to offer a few remarks shewing briefly the causes to which we attribute the late sickness at that station, and the extent to which they may be removed or palliated.

21st. The insalubrity of Kurnaul has been ascribed to various causes :—to the prevalence of an epidemic influence, of late years, over the North Western Provinces—to its proximity to the Jumna khadir on the east, and to the unhealthy flats of Kythul on the west—to the stiff and retentive nature of its soil—to the swamps bordering on the canal—to the extent of rice cultivation—and to the naturally imperfect drainage, being still further obstructed by the canal embankments. Each of these causes, and especially the first named, have, in our opinion, contributed to the unhealthiness of Kurnaul. Some of them are obviously irremediable, but we are satisfied of the practicability of reclaiming the

canal swamps, of improving the surface drainage by carrying off the superfluous water under the canal by two tunnels to the Jumna, and of prohibiting irrigation within two miles of the Cantonment pillars. We have no doubt that the adoption of such measures would be attended with beneficial results; but believing that the level of the springs has been permanently altered, and the under strata of the soil saturated with moisture, we cannot confidently prognosticate that they would ensure the complete restoration of salubrity.

22nd. In the foregoing paragraphs, we have confined ourselves to general conclusions, purposely omitting the chain of induction by which they have been formed on the observed facts, as recorded in the figured abstracts in the Appendix E. A full discussion of the complicated considerations which have influenced our opinions would have extended this report to an undue length, and might probably have hindered rather than facilitated the formation of a correct judgment on the important question at issue. The facts, however, are recorded for reference, and will be found, on careful examination, to support our opinions.

23rd. In conclusion, we beg to record our obligations to the Honorable the Lieutenant Governor, North Western Provinces, for the assistance he has afforded us, both privately and officially, in the prosecution of our enquiries. On his requisition, we have received from the Madras Government a report on a remarkable epidemic that pervaded the southern districts of that Presidency in 1809, 1810, and 1811, an abstract of which will be found in Appendix H., and at his suggestion we have obtained the appended reports from Drs. Kier and Collyer, shewing that tank irrigation, as practised in certain districts of Rajpootana, is consistent with a high degree of salubrity. These documents possess much interest with reference to the subject of our enquiry, and have had their due influence on our general conclusions.

(Signed) W. E. BAKER, *Major, Engineers,*
President.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Bgde. Horse Artillery,
Member of Committee.

I fully concur in the substance of this report, but as a change in my ordinary duties since I was appointed a member of this Committee has prevented my taking any active share in its proceedings, my signature here is merely formal.

(Signed) H. YULE, *Lieutenant,*
Engineers,
Member of Committee.

APPENDIX A.

I would willingly have confined myself strictly to the facts before [redacted] Committee, did I not consider it necessary, in order that these very facts should have due weight and consideration, first, fully to meet an argument often advanced by intelligent persons interested in canal irrigation, and believed by them [redacted] unanswerable, [redacted] alone to prove the doctrine of malaria a [redacted] fiction of medical writers, and to render all further enquiry unnecessary, viz., that some marshes can be pointed out which do [redacted] [redacted] fevers to any extraordinary extent; and some perfectly dry localities, where fevers of a very malignant nature abound.

That certain local peculiarities [redacted] *generally* connected, as cause and effect, with certain diseases of the human body, is [redacted] hypothesis of any set of medical speculators, but a belief which has forced itself [redacted] the conviction of mankind in various ages and countries. What those conditions [redacted] which are [redacted]ssential to the production of endemic disease, and what [redacted] accidentally associated with them, how the poison [redacted] evolved, and what [redacted] its sensible properties and chemical composition, have indeed furnished ample grounds for medical speculation [redacted]d controversy; but the general proposition itself is [redacted] fair and legitimate [redacted] induction from observed facts, [redacted] any within the whole range of science.

Exceptions do not confirm a rule, but neither do they overturn a fair induction. They only shew that [redacted] knowledge is incomplete, and the whole law of the case not fully understood. If, [redacted] the exact sciences, residual phenomena are constantly occurring; something happening which [redacted] unlooked for; something expected which does not take place; how much [redacted] may they be anticipated in such [redacted] science [redacted] medicine, where the sources of error are at once so numerous and perplexing?

Mankind, not physicians alone, have agreed, that typhus fever is a highly contagious disease. Suppose (what would not be difficult) that I collect a dozen authentic cases of persons, who have freely exposed themselves to this contagion, and who, notwithstanding, entirely escaped the disease, am I therefore to shut my eyes to the thousands of instances [redacted] which the complaint [redacted] communicated under like circumstances, and to reject the whole doctrine of contagion [redacted] untenable? Surely this would be generally condemned [redacted] a dangerous and inexcusable error! The human r[redacted] have, at least, [redacted] deep a concern in the laws of malaria, as in those of contagion.

It is [redacted] remarkable and most important fact, that the diseases believed to arise from malaria, are, beyond all comparison, more prevalent during and immediately after the periodical rains in India, than at any other season of the year; and that this is precisely the time when the conditions everywhere alleged to be necessary to the production of that poison, [redacted] also, beyond all comparison, most abundant. At some places, there may be more, and [redacted] others less; in some years more, and [redacted] others less; but the truth of the general remark may be verified, in this country, at all places, and in all years.

When we remember the feeble affinities which hold together the constituents of vegetable matter, the numerous and totally dissimilar combinations into which they may enter, and the seemingly trifling accidental circumstances which may determine the nature of the new compound, it is not unreasonable to believe, that a *something* capable of causing human disease, may be evolved during the decomposition of such substances, under the action of heat, moisture, and electricity; [redacted] to conceive, that unappreciable, [redacted] at least unnoticed modifications of these conditions, or of the chemical state of neighbouring bodies, may alter the nature of the expected product, and obstruct the formation of the poison when most confidently looked for. For instance, [redacted] may make all the usual arrangements for vinous fermentation; an unexpected and unobserved change takes place in the temperature or electric condition of the atmosphere, and *vinegar* not wine is the result. Is malaria alone [redacted] be a constant and unvarying product of such complex operations, even though all the ordinary conditions are apparently present?

Again, if we admit that a certain class of fevers arise from malaria, does it necessarily follow, that all endemic fevers must originate in the [redacted] cause, or that all malaria [redacted] necessarily one and the same? Or who has demonstrated that malaria, like carbonic acid gas (an aëriform fluid, to which in some points it bears a striking analogy) may [redacted] be evolved under several and very different apparent conditions?

All our previous knowledge and experience would lead us to suspect some mischief from irrigating canals in such [redacted] climate as that of India, especially, if not expressly constructed so [redacted] preserve the drainage of the country, and effectually to control the immoderate use of the water; and all I contend for is, that the question be tried and decided by the facts strictly bearing on the case before us, and not by a few exceptions, however striking or inexplicable, found [redacted] other distant situations [redacted] countries.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Brigade Horse Artillery,
Member of Committee.

APPENDIX B.

The first indispensable step [redacted] the present enquiry was to obtain [redacted] certain mode of determining the relative salubrity of different districts irrigated by the canals, irrigated by wells, [redacted] altogether unirrigated. In [redacted] European countries at the present day, this would have been easy [redacted]gh, by the mere comparison of the known medical statistics [redacted] the several localities under examination; but in India, the difficulties were at first sight almost insurmountable. Here, we had no record [redacted] diseases, births, deaths, and population, to which [redacted] could refer. A native's account of the healthiness of his [redacted] town, [redacted] village, even for one season, [redacted] the loosest and most vague of statements, and if employed to collect positive data, his written report is not [redacted] whit more to be depended on. The aspect of the people is always [redacted] matter liable to error and difference [redacted] opinion; and the important subject of longevity cannot even be approached, for no native knows his [redacted] age correctly, least of all those advanced in years. The records of military hospitals were good and valuable data as far [redacted] they went; but they applied only to a few widely distant points, and referred to a class of subjects, differing in all important particulars from the native inhabitants of the towns or the agricultural population of the country.

In this difficulty, it occurred to me, that the inhabitants of [redacted]s countries, but especially the native inhabitants of unhealthy districts [redacted] India, often carry in their own persons [redacted] record of past suffering, which can at all times be easily read, and which [redacted] one [redacted] either falsify [redacted] suppress. This is enlargement of [redacted] spleen, [redacted] disease to which the native of India [redacted] peculiarly liable, and which, if [redacted] the invariable consequence of miasmatic fever, is so constantly associated with it, that the one may (on the large scale) be safely taken [redacted] the [redacted] of the other, [redacted] least, of that malaria from which both unquestionably spring. But [redacted] this is a test which has never before (to my knowledge) been used for the [redacted]e purpose, and [redacted] many of our conclusions are based on the results with which it has furnished us, I trust I shall be permitted to enter somewhat fully [redacted] the subject.

There is [redacted] fact more generally known [redacted] unhesitatingly admitted by medical men, than that disease of the spleen is [redacted] of the most frequent consequences of malarious fevers. To enumerate all the authorities on this point, would be to quote most of the respectable writers [redacted] these subjects; but that Government may appreciate the value of the test I chiefly depend on for the purpose of determining the comparative intensity of malaria in different localities, it will be proper to cite [redacted] few [redacted]sages from two recent and well known works, by authors, respectively, of European and Indian experience.

"In moist countries, whether [illegible] or temperate, they (diseases of the spleen) "are endemic, as in Italy, Holland, South America, and some parts of India, *in* "*fact wherever malaria exists.*"

"The most frequent causes of enlarged spleen are ague and remittent fever." —*Cyclopædia of Practical Medicine.*

"The most part of the cases of vascular enlargement of the spleen in this "country (Bengal) follow intermittent and remittent fevers, and tumid spleen "may be stated [illegible] the most invariable consequence of acute and debilitating dis- "ease among children of weak constitutions in Bengal.

"The assemblage of constitutional symptoms described in the foregoing pages "constitutes *the endemic cachexia of those tropical countries that are subject to* "*paludal exhalations*; the enlargement of the spleen is the most frequent attend- "ant [illegible] that cachexia; and its increase or subsidence generally corresponds with "the unfavorable or favorable changes which are taking place in the constitution.

"Disease of the spleen is much more frequent in those years in which the "most obstinate, fatal, and protracted remittents prevail." "The history of the "fevers of St. Domingo and of Minorca by Jackson and Cleghorn shew how fre- "quently disease of the spleen is connected with the autumnal fevers of these "countries. But great heat is not essential to the production of that disease. It is "the autumnal endemic of Holland, of the low parts of Hungary, of the marshes of "Lombardy; and it is by no means rare in the fens and marshes of England. In "fact, enlargement of the spleen *is frequent wherever intermittent and remittent* "*fevers prevail.*"—*Twining's Diseases of Bengal.*

Such passages might be multiplied to a great extent, but the above will, I hope, suffice to establish the value of this kind of evidence, as a probable measure of the existence and intensity of malaria in any particular situation.

I may here remark that *Ague cake*, the name by which enlarged spleen is commonly known to the country people in the fenny districts of England, is a happy translation of *Tup tillee*,* the words used by the up-country Indian peasants to express the same disease.

Although the intimate connexion between malarious fevers, and organic disease of the spleen is established beyond a doubt, it never [illegible] supposed that these diseases bear an *exact* proportion to each other, or that the number of enlarged spleens in any particular situation, should correspond precisely with the number

* Literally, fever spleen.

of attacks of fever suffered by its inhabitants. Many fevers occur, (especially if the attacks have been slight and not often repeated) without being followed by enlargement of the spleen; and many tumid or slightly inflamed spleens become natural in size and structure, soon after the fever has passed off. On the other hand, the spleen may become enlarged from other causes, and in persons who have had no distinctly developed paroxysm of fever, although living in a malarious locality. Such cases, however, are, according to my experience, comparatively very rare.

When I first began to apply this test, I was not aware of its full value. I did not then know the extraordinary susceptibility of the natives, especially the native children of these provinces, to disease of the spleen; nor could I, before trial, have anticipated the facility with which it points out the relative salubrity of different situations, and at once detects unhealthy localities, which could not otherwise be discovered without the experience and observation of several seasons.

It must not, however, be supposed that this disease exists *everywhere* to a considerable extent, among the inhabitants of the North Western Provinces. Places in close proximity, but in otherwise different local circumstances, exhibit the most wonderful differences in this respect; and in some extensive tracts of country, the complaint is scarcely to be met with. On the other hand, it is important to guard against exaggerated notions of the physical condition of the inhabitants of certain situations where so large a proportion are afflicted with this description of organic disease.

Enlargement of the spleen is the least formidable of all organic diseases of the viscera; and is chiefly important as a symbol of another complaint, which generally has preceded, and may come after it. The lesser varieties (marked in the figure O. and S.) and which also form the great mass of the cases registered, may consist with every outward *appearance* of health and vigor. In most places where the disease is common, many strikingly healthy looking men and children were found with decided enlargement of the spleen. But the larger varieties, (M.L.VL.) of which but a comparatively small number are recorded, are usually accompanied with a sickly (cachectic) aspect.

Other diseases besides fever arise from malaria, and other consequences than spleen follow severe and protracted attacks of fever; but most of these can be effectually concealed, and none can be detected with such ease and certainty as enlargement of the spleen. Indeed, without this test, the whole inquiry must have ended in vague and unsatisfactory conjecture, and without a single fact collected among the agricultural population, on which we could depend.

I have [redacted] wish to exaggerate the true and legitimate value [redacted]f the spleen test, [redacted] do I venture to assert that it will indicate the presence of the remote causes of *all fevers*, or even of all pure endemic diseases of this class. There may be different kinds [redacted] malaria, giving rise to fevers of different types, and having different complications and consequences; or common continued and typhoid fevers may become mixed up with, and modified by, fevers of local origin. All these [redacted] worthy subjects of future inquiry. But from what I have lately witnessed, I [redacted] fully persuaded, that it will be found [redacted] true and faithful comparative measure of *marsh malaria* in its extended sense; and with *that* alone, have canals and canal irrigation any proper connexion.

It [redacted]as not, however, until after we had examined the Cantonment of Meerut, that my own faith in the practical utility of the spleen test was fully established. Hitherto, spleen disease had borne some distinct relation to the nearness of water to the [redacted] face, and in [redacted] few instances where [redacted]ater was *very close*, we had found the almost incredible number of about 70 per cent. of the inhabitants with enlarged spleens. Was the disease then caused by moisture alone, and not always connected with marsh fevers? Meerut seemed well calculated to verify [redacted] disprove the received opinion; for in it [redacted] had [redacted] *known* healthy locality, with water only about 12 feet from the surface.

Four separate observations were made in different parts of that large station, and out of 160 native residents examined, only 3 cases of spleen were found; none above average size.

The city of Delhie appears, [redacted] first sight, [redacted] instance in which the test failed; but on careful examination, I think it will only be found to furnish a striking confirmation of its general accuracy. The medical topography of the City, Civil Station, and Military Cantonment of Delhie, [redacted] an extremely complicated subject, and involves a great variety of important considerations, but I need only briefly notice in this place the following particulars.

Within the walls, and especially in the most dense and crowded quarters of the city, there were comparatively few indications of pure malarious disease. This accords with what has often been remarked in other countries, viz. That the high walls, and narrow crowded smoky streets of large cities, are frequently a safe-guard against marsh miasma, although other causes of disease may abound in such situations.

In the Cantonment Bazar, and suburbs outside the walls, [redacted] considerable amount of spleen disease was found. But when we proceeded to examine the vil-

lages situated [redacted] the verge of the low moist "khadir" land, immediately in front of the old sapper lines, (a position now abandoned in consequence of its extreme insalubrity) the test at once pointed out malaria in its *highest intensity.*

(Signed) T. E. DEMPSTER, *Surgeon,*

1st Brigade Horse Artillery,

Member of Committee.

APPENDIX C.

Particular account of the manner of conducting the medical examinations.

It is for many reasons of great importance, that I should particularly describe the manner in which the spleen examinations have been conducted.

At each place 20 children and 20 male adults were selected, our chief care being, to take a *fair sample*, not of the sick, but of the " going about" population of the town [redacted] village under inspection. The avowedly diseased were discouraged from coming forward, and when brought were rejected, unless there were not others sufficient to make up the required number. We took subjects from all castes, and, whenever it was practicable, examined a certain number of the agricultural laborers found in the adjoining fields, before entering the village, where our numbers were completed from other classes. Each adult was asked his caste, if he had had fever this year, last year, or the year before last. The children were only questioned as to caste. Major Baker generally pointed out the subjects. I conducted the medical examination, [redacted] Major Baker entered the result in his note-book.

As the great object was to make [redacted] of an unequivocal, but easily applied test, no [redacted] was ever registered as " spleen," *unless I had so distinctly felt the enlarged organ that it could not be confounded with any other disease.* When the abdomen was natural and the muscles soft and yielding, a satisfactory examination was generally obtained [redacted] the erect position ; but if the belly was rigid, and the region of the spleen tumid, but not clearly defined, the subject was put flat [redacted] his back, with the knees bent and raised. If an enlarged spleen was not discovered after a *moderately careful* examination so conducted, the person was registered as *free from the disease.* Sometimes, though rarely, really doubtful cases were met with, which could not at once be pronounced upon ; these were put aside, and others examined in their stead.

It will be obvious to medical men, that if all [redacted] subjects had been examined in a variety of postures, and [redacted] various states of the stomach and bowels, several cases of spleen would have been detected, which necessarily escaped my notice. But then this test would [redacted] longer have been [redacted] *easily applied* one, besides occupying a far longer time than we could afford to bestow on each village. The disease is not only so common, but [redacted] general [redacted] easily detected after a little practice, that we could afford to sink [redacted] cases not easily found, and as *precisely the same*

mode of examination was followed everywhere, it everywhere furnished a fair scale of comparison.

One-half of the subjects selected for examination, was in all practicable cases composed of children under the age of puberty, 1st, because I believed young persons to be more liable to enlargement of the spleen than adults, and 2ndly, because the disease, when present, is in them, more easily and certainly detected. For both these reasons, I considered children to be the more delicate test of malaria. The results amply confirm this opinion.

As the size to which the spleen attains is a very important feature of the disease, and most probably indicative of the intensity of the remote cause, I adopted a simple plan of noting 5 different degrees of size, which will be at once understood by reference to the annexed figure.

O. Signifies a distinctly marked case of spleen.

M. One decidedly larger than O, and the mean between the five varieties.

L. A large spleen extending to, or near to the navel.

VL. A very large one passing across the medial line.

S. A small but perfectly marked case of the disease.

The soft enlargements were seldom registered, even when they presented themselves. I was generally obliged to put them aside among the "doubtful cases;" for although very confident, as to the real nature of the disease, a mistake was possible. But when I felt a solid tumour in the left side, distinctly ascertained its shape, consistence, and the direction of its edge, and hence knew that such could only be an enlarged spleen, in so registering it, we recorded a *fact*, not a mere medical *opinion*, resting of course on the credibility of the witness.

The very large spleens sometimes met with in bad localities, were rarely admitted into our returns, because the subjects usually presented themselves as "volunteers," and according to the rule adopted, were rejected.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Brigade Horse Artillery,
Member of Committee.

APPEN

ABSTRACT shewing the comparative salubrity of seven different Military

Years.	Native Troops.											
	Loodiana.		Kurnaul.		Hansi.		Delhi.		Meerut.		Muttra.	
	Per centage of admissions.	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*
1825	0	0	0	0	0	0	0	0	25	0¾	28	0 3-10th
1826	17	0¼	29	0 1-5th	25	0½	61	0 5-6th	38	1⅓	6	0
1827	27	0 3-5th	30	0⅓	32	0½	55	1	49	1	35	0 6-10th
1828	23	0 1-6th	21	0⅓	45	0¼	45	0½	24	0 1-5th	23	0 3-10th
1829	65	0 4-5th	48	0⅔	137	1⅜	123	1⅓	52	0½	6	0
1830	42	0¼	45	0 2-5th	84	0¾	113	1 1-5th	52	0¼	0	0
1831	27	0 2-7th	44	0 2-5th	38	0½	77	0 1-5th	41	0⅓	52	0 8-10th
1832	37	0 3-5th	69	0⅔	21	0 1-10th	41	0¼	41	0⅔	36	0 4-10th
1833	47	0⅓	46	0 2-8th	48	1⅓	62	0⅓	31	0 2-5th	32	0 9-10th
1834	36	0 1-5th	39	0 1-5th	142	1¼	41	0¾	27	0⅛	46	0 9-10th
1835	58	0½	84	1⅓	57	0¼	72	1	55	0 4-9th	60	0 7-10th
1836	29	0⅓	55	0⅓	44	0 1-12th	61	0½	56	0 4-5th	46	0 7-10th
1837	46	0 3-5th	67	1	181	1 5-6th	63	0⅓	44	0¼	23	0 4-10th
1838	55	1¼	93	1 1-10th	162	1 1-6th	71	1	52	0 5-9th	66	3 1-10th
1839	47	0¼	54	0⅓	160	0½	72	0 3-5th	49	0 3-5th	44	0 4-10th
1840	47	0½	43	0⅓	185	0¼	57	0 3-7th	36	0⅔	81	0 4-10th
1841	67	1	84	1¼	264	1 1-5th	157	1 1-9th	69	1	27	0 3-10th
1842	82	1	115	1 1-8th	119	0 4-5th	295	1⅓	199	1 1-9th	41	0
1843	91	2½	0	0	111	1½	377	3	116	1	101	3
1844	141	2 4-7th	0	0	93	1	342	3½	115	1 1-8th	62	0 6-10th

The above table is compiled chiefly from returns furnished by the Medical Board, head of that station, have been extracted from a printed Table by Dr. John Murray, inaccurate.

DIX D.

Stations in the NORTH WESTERN PROVINCES, from [illegible] 1844.

EUROPEAN TROOPS.

Agra.		Loodiana.		Kurnaul.		Meerut.		Muttra.		Agra.	
Per centage of admissions.	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*
42	4 2-5th	0	0	0	0	107	2¼	14	0	335	2 9-10th
0	0	0	0	76	14¼	112	2⅓	0	0	0	0
31	1	0	0	148	3¾	206	3 1-5th	175	4¾	235	4 4-5th
15	0¼	0	0	140	3¼	175	3½	115	1 1-10th	228	2 7-10th
0	0	0	0	198	3½	152	3 1-5th	0	0	0	0
0	0	0	0	140	2½	145	2½	0	0	0	0
40	0½	0	0	130	2¾	118	3	161	2 9-10th	144	3
46	0⅔	0	0	136	3 2-5th	94	3½	75	0	102	1 5-9th
56	0⅞	0	0	68	2 5-6th	78	1 5-6th	82	6	112	2⅓
59	0⅔	0	0	60	3	88	2¼	86	11	109	1⅑
78	1 4-7th	0	0	64	1½	78	2⅔	88	0	124	1 1-9th
36	0 5-6th	0	0	130	1⅔	97	4	142	4 7-10th	126	2½
69	1¼	0	0	157	2 3-10th	75	1 3-7th	82	0 9-10th	116	4
173	5¾	0	0	201	7¼	121	4⅓	176	11½	225	7½
92	1¼	100	2 2-5th	171	5	138	2 5-7th	120	8¾	159	5¼
125	1½	94	3½	152	3 2-5th	113	2¼	99	1	151	3
79	1 3-5th	109	1 4-5th	272	7¾	172	3½	146	1 1-10th	118	1 7-10th
144	1 1-10th	149	4½	309	9¼	316	3 3-5th	69	1	110	1 3-5th
87	1⅔	185	3⅔	0	0	230	4	124	6¾	141	5 3-5th
99	1 3-5th	189	3 1-5th	0	0	307	3 3-5th	124	1 9-10th	125	3 3-10th

Those for Kurnaul having been returned for correction,* the few entries made under

The returns for Meerut and Delhi for the years 1842, 1843 and 1844, are stated to be

(Signed) W. E. BAKER, *Major, Engineers,*

President.

(Signed) T. E. DEMPSTER, *Surgeon,*

Member.

* Subsequently received, and the deficiencies supplied except for the year 1843, which is still incomplete.

ABSTRACT of Medical Examinations of 26 Irrigating Villages

Villages.	Children of all Classes.		Adults.													
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c., &c.*		*Menials.*		*Totals.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Hansi, ...	36	24	0	0	8	0	8	4	6	4	18	6	3	3	43	17
Hissar, ...	17	23	4	0	8	2	9	0	5	1	6	4	1	0	33	7
Kharrur, ...	16	4	1	0	15	2	0	0	0	0	0	0	2	0	18	2
Raipoor, ...	10	10	0	0	13	7	0	0	0	0	0	0	0	0	13	7
Satrouda, ...	11	9	3	0	11	3	0	0	0	0	0	0	2	1	16	4
Sulems Thekopoor, ...	8	12	0	0	4	4	5	4	0	0	1	1	1	0	11	9
Shahpoor, ...	4	16	0	0	12	2	0	0	0	1	1	2	2	0	15	5
Maturshaum, ...	11	9	5	1	10	2	0	0	0	0	2	0	0	0	17	3
Mir[illegible] Khera, ...	3	12	0	0	4	1	6	2	5	6	1	0	1	0	17	3
Sulemgurh, ...	10	10	2	1	4	3	2	1	1	0	0	1	3	2	12	8
Kabrere, ...	9	11	0	0	8	1	4	0	0	2	0	0	4	1	16	4
Siswal, ...	8	12	1	0	8	2	0	0	2	1	2	1	3	0	16	4
Kheree, ...	11	9	2	1	8	5	0	0	1	0	1	2	0	0	12	8
Majra, ...	5	15	2	2	2	7	1	0	0	1	1	1	2	1	8	12
Narnound, ...	12	8	0	0	12	2	0	0	4	0	0	0	0	2	16	4
Rajthal, ...	12	8	0	0	11	6	1	1	0	0	1	0	0	0	13	7
Bamra, ...	13	7	12	2	0	0	0	0	0	2	2	0	2	0	16	4
Jheend, ...	28	12	7	3	6	1	2	0	8	0	5	4	1	0	29	11
Kokhree, ...	12	8	2	0	10	1	0	0	0	0	2	0	2	0	16	4
Bohutwala, ...	8	12	1	1	9	5	0	0	1	0	0	1	0	2	11	9
Dhatrut, ...	8	12	2	0	5	2	5	0	4	0	1	1	0	0	17	3
Jamunee, ...	9	11	4	1	6	3	0	0	0	1	3	2	0	0	13	7
Rojana, ...	11	9	6	3	5	4	0	0	1	0	0	0	0	1	12	8
Saffeedhun, ..	15	5	2	1	0	0	9	2	4	0	0	1	0	1	15	5
Barounde, ...	5	8	0	0	0	0	9	5	2	0	1	0	1	2	13	7
Jesshee, ...	3	17	1	2	11	3	0	0	0	1	1	0	1	0	14	6
	300	293	57	18	190	74	61	19	44	14	49	27	31	16	432	168

situated within half a mile of the Hansi branch of the Western Jumna Canals.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of size of enlarged spleens.*					
					Tor.	Daul.	Total.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	[illegible]	S	Total.
43	33	20	34	55	5270	250	5520	700	1	4	3	21	12	41
22	22	12	37	81	580	1000	1580	0	0	3	5	17	5	30
45	20	5	15	84	940	160	1100	120	0	0	0	4	2	[illegible]
55	10	35	42	96	350	200	550	75	0	0	2	11	4	17
45	50	30	32	95	25	125	150	0	0	0	1	[illegible]	4	13
45	65	20	52	0	25	125	150	0	0	1	4	15	1	21
60	65	15	52	0	325	50	375	0	0	0	3	14	4	21
65	35	10	30	0	315	80	425	5	0	0	1	6	5	12
55	40	30	37	0	325	75	400	10	0	0	1	7	7	15
70	60	15	45	30	725	75	800	25	0	1	4	11	2	18
55	50	15	37	0	650	50	700	50	0	1	0	5	9	15
55	50	10	40	72	1130	170	1300	0	0	0	2	10	4	[illegible]
50	55	30	42	60	775	25	800	150	0	2	3	7	5	17
75	60	25	67	0	1595	25	1620	295	0	0	4	14	[illegible]	27
75	50	30	30	107	3350	50	3400	700	0	3	5	3	1	12
45	40	20	37	0	200	350	550	20	0	1	5	7	2	15
35	20	10	27	145	200	350	550	20	0	0	0	6	5	11
50	25	20	29	0	1400	500	1900	450	0	0	5	[illegible]	10	23
45	15	15	30	0	400	150	550	160	0	0	1	6	5	[illegible]
75	75	70	52	0	825	125	950	240	0	2	4	14	1	[illegible]
35	25	10	37	145	1775	125	1900	500	0	0	0	9	[illegible]	15
70	60	20	45	145	775	175	950	260	0	0	4	9	5	18
50	30	30	42	0	1075	175	1250	370	0	1	3	9	4	17
50	35	50	25	139	425	175	600	125	0	0	0	7	3	10
30	45	25	45	0	330	20	350	60	0	0	3	10	2	15
45	40	10	57	36	725	175	900	150	1	0	4	13	5	23
50	41	22	39	92										

ABSTRACT of Medical Examinations of 5 Irrigating villages situate

Villages.	Children of all Classes.		Adults.									
			Brahmins, Fukeers, &c.		Hindoo cultivators.		Mussulman cultivators.		Bunnias.		Artisans, &c.	
	N	E	N	E	N	E	N	E	N	E	N	E
Nianna, . .. — ..	18	[illegible]	2	0	11	0	1	0	1	[illegible]	1	0
Akburpoor Nowlee, ..	17	3	0	0	13	2	0	0	1	1	1	0
Booreana, — — ..	12	[illegible]	0	0	15	2	0	0	0	0	0	1
Ameerpoor Bheinee, ..	9	11	3	0	14	1	0	0	0	0	0	0
Dalimwala, ...	16	4	1	0	15	0	0	0	[illegible]	0	1	0
	72	28	6	0	68	5	1	0	4	1	3	1

half a mile or more from the Hansi branch of the Western Jumna Canals.

Adults.				Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Annual average amount of canal irrigation.			Average annual amount of irrigated rice.	Detail of sizes of enlarged spleens.					
Menials, &c.		Totals.							Tor.	Daul.	Total.							
N	E	N	E	1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
4	0	20	0	15	15	10	5	106	275	100	375	20	0	0	0	0	2	2
2	0	17	3	75	40	20	15	0	90	10	100	0	0	0	0	3	3	6
1	1	16	4	40	45	25	30	117	not known	not known	not known	0	0	0	0	6	6	12
2	0	19	1	80	20	20	30	124	1480	20	1500	225	0	0	1	7	4	12
1	0	20	0	30	35	5	10	127	510	106	616	110	0	0	0	3	1	4
10	1	92	8	40	31	16	18	118										

ABSTRACT of Medical Examinations of 7 Irrigating villages distant half

VILLAGES.	CHILDREN OF ALL CLASSES.		ADULTS.									
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E
Chota Oorlana, ...	11	9	0	0	0	0	14	2	0	0	2	0
Burra Oorlana, ...	11	9	2	0	1	0	14	0	1	0	0	0
Seenk, ...	17	3	0	0	13	4	0	0	1	0	0	0
Burra Anc[illegible], ...	15	5	7	0	7	0	0	0	2	0	2	1
Gungana, ...	17	3	5	0	8	1	0	0	1	0	3	0
Bootana,..	19	1	2	0	12	2	0	0	2	0	0	0
Barouda,..	19	1	0	0	11	0	1	0	1	1	5	1
	109	31	16	0	52	7	29	2	8	1	12	2

a mile or more from the Bootana branch of the Western Jumna Canals.

Adults. Menials.		Adults. Totals.		Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Annual average amount of canal irrigation. Tor.	Daul.	Total.	Average annual amount of irrigated rice.	Detail of sizes of enlarged spleens.					
N	E	N	E	1844	1845	1846		Feet	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
1	1	17	3	45	40	25	30	0	475	25	500	100	0	0	0	8	4	12
2	0	20	0	45	55	40	22	106	1300	150	1450	200	0	0	2	2	5	9
0	2	14	6	50	30	20	22	109	1800	150	1950	200	0	0	0	6	3	9
1	0	19	0	50	25	20	15	128	745	5	750	20	0	0	0	5	1	6
2	0	19	1	20	15	20	10	99	2025	50	2075	80	0	0	0	4	0	4
2	0	19	2	60	60	30	7	82	3430	50	3480	500	0	0	0	3	0	3
0	0	18	2	20	30	0	7	78	4500	50	4550	20	0	0	0	1	2	3
8	3	125	15	41	30	22	16	102										

ABSTRACT of Medical Examinations of 22 Villages situated

Situation.	Villages.	Children of all classes. N	Children of all classes. E	Adults. Brahmins, Fukeers, &c. N	Brahmins, Fukeers, &c. E	Hindoo Cultivators. N	Hindoo Cultivators. E	Mussulman Cultivators. N	Mussulman Cultivators. E	Bunias. N	Bunias. E
Nujufgurh Jheels.	Runhowla, ...	9	11	2	1	10	2	0	0	0	[illegible]
	Baprowla, ...	11	9	1	2	8	4	0	0	1	[illegible]
	Nujufgurh, ...	17	3	2	2	0	6	4	0	4	2
	Nugla, ...	2	18	0	2	8	5	0	0	0	[illegible]
	Pandwala, ...	4	16	2	7	3	6	0	0	0	[illegible]
	Oojwa, ...	8	12	0	1	9	2	1	2	1	[illegible]
	Shumushpoor, ...	4	16	0	0	11	7	0	0	0	[illegible]
	Isheepoor, ...	19	1	2	0	9	4	0	0	3	[illegible]
	Badlee, ...	11	9	2	0	7	0	0	0	2	1
Jumna West Khadir.	Duheerpoor, ...	3	17	0	3	7	5	0	0	0	2
	Indurput, ...	12	7	4	0	7	1	2	0	1	[illegible]
	Newul, ...	8	12	0	1	0	0	7	8	0	[illegible]
	Mogul Majra, ...	7	13	1	1	6	1	3	2	0	1
Jumna East Khadir.	Luknowtee, ...	10	16	1	0	1	0	2	0	2	1
	Soorajpoor, ...	7	13	0	1	2	1	9	3	0	[illegible]
	Shahdera, ...	11	[illegible]	1	1	3	1	3	1	3	1
	Joondla, ...	4	16	6	1	9	3	0	0	0	[illegible]
Valley of the Hindun.	Arthulla, ...	20	0	1	0	3	0	7	1	1	[illegible]
	Kurrara, ...	14	6	0	0	17	0	0	0	0	[illegible]
	Ghazeeoodeennuggur, .	14	[illegible]	4	0	0	0	5	1	0	[illegible]
	Gokuna, ...	14	6	0	0	10	2	0	0	0	[illegible]
	Ghorao, ...	13	7	5	0	1	0	4	0	1	[illegible]
		223	217	34	23	131	44	47	18	25	8

near the Nujufgurh Jheels or in the Khadir lands of Rivers.

Adults. Artisans, &c. N	Artisans, &c. E	Menials, &c. N	Menials, &c. E	Totals. N	Totals. E	Per centage of adults having suffered from fever in 1844	1845	1846	Per centage of enlarged spleens.	Depth of water below surface of ground. Feet.	Detail of sizes of enlarged spleens. V L	L	M	O	S	Total.
0	1	4	0	16	4	70	45	30	37	17	0	0	3	7	5	15
3	0	0	1	13	7	55	70	40	40	15	0	0	0	8	8	16
4	2	0	6	14	6	25	45	70	22	19	0	0	0	8	1	9
2	2	1	0	11	9	65	75	60	67	10	0	0	0	19	8	27
0	2	0	0	5	15	45	60	85	77	5	0	1	7	16	4	31
1	0	1	2	13	7	25	60	70	47	11	0	1	3	12	3	19
0	0	2	0	13	7	35	90	65	57	7	0	1	2	16	4	23
1	0	1	0	16	4	15	25	50	12	27	0	0	0	4	1	5
3	3	1	1	15	5	45	65	40	35	20	0	0	1	6	7	11
0	0	1	2	8	12	50	25	25	72	7	0	3	3	16	7	29
2	0	1	2	17	3	55	40	50	25	10	0	0	0	3	7	10
2	0	2	0	11	9	50	15	20	52	11	0	0	3	15	3	21
1	0	4	0	15	5	40	60	20	45	10	0	1	3	10	1	18
6	0	5	2	17	3	55	45	15	32	18	0	0	0	9	4	13
1	3	0	0	12	8	35	40	25	52	10	0	0	2	12	7	21
3	2	0	1	13	7	65	60	40	40	15	0	2	3	8	3	16
0	0	1	0	16	4	40	40	25	50	8	0	0	0	7	13	20
0	0	1	0	19	1	15	25	30	2	12	0	0	0	0	1	1
2	0	1	0	20	0	20	20	10	15	14	0	0	0	1	5	6
0	1	3	0	18	2	70	45	45	20	38	0	0	0	2	6	8
2	0	2	0	14	2	60	81	60	22	13	0	0	0	5	3	8
4	1	4	0	19	1	35	25	30	20	17	0	0	1	4	3	8
43	17	35	11	315	121	44	49	42	38	15						

ABSTRACT of Medical Examinations of 22 villages situated within

Villages.	Children of all Classes.		Adults.													
			Brahmins, Fukeers, &c., &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunias.*		*Artisans, &c., &c.*		*Menials.*		*Total of adults.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Kurnaul, ...	30	56	6	0	12	4	5	4	11	10	19	5	4	6	57	23
Phoorluk, ...	7	13	6	0	5	0	0	1	0	5	1	0	1	1	13	7
Raipoor, ...	6	14	3	1	6	2	1	0	2	0	4	1	0	6	16	4
Dhurmgurh, ...	5	15	0	4	10	2	0	0	0	0	2	2	0	6	12	8
Shera, ...	5	15	1	1	9	7	0	0	1	0	0	0	0	1	11	9
Mudlowda, ...	8	12	2	0	7	7	0	0	1	0	1	[illegible]	1	1	12	8
Kokrana, ...	11	9	0	0	5	5	0	0	1	0	2	2	3	2	11	9
Didwaree, ...	1	19	1	0	5	6	2	2	1	1	0	1	0	1	9	11
Chumrara, ...	1	16	2	1	7	4	0	1	0	1	0	1	2	1	11	9
Bullee, ...	8	12	1	2	3	2	1	0	1	2	2	0	2	4	10	10
Mahomedpoor Majra, ..	2	18	1	2	6	4	0	0	2	1	0	2	1	1	10	10
Sitaolee, ...	5	15	0	1	6	6	0	0	2	1	2	2	0	0	10	10
Jooah, ...	3	17	3	1	5	3	0	0	0	3	1	4	0	0	9	11
Jajhee, ...	5	15	4	0	4	6	0	1	0	0	0	3	1	1	9	11
Bhutgong, ...	5	15	1	4	3	8	0	1	0	1	0	1	1	0	5	15
Jharouth, ...	2	18	2	1	7	5	0	0	1	0	0	3	1	0	11	9
Jutowla, ...	3	17	1	5	3	6	0	0	1	1	1	1	0	1	6	14
Bowanna, ...	3	17	1	1	5	6	1	0	2	2	0	0	1	1	10	10
Hydurpoor, ...	4	16	1	2	4	5	0	0	2	1	1	1	2	1	10	10
Subzee Mundee, ...	10	10	0	0	5	1	0	0	2	2	7	3	0	0	14	6
Rohilla Khan Serai, ..	8	12	2	1	2	1	3	2	1	0	5	2	0	1	13	7
Delhi,*	60	20	3	[illegible]	5	0	0	0	28	3	33	3	2	3	71	9
	195	365	41	27	124	90	13	12	59	34	81	37	22	20	340	220
* Delhie City, ...	47	13	1	0	[illegible]	0	0	0	22	0	25	3	2	2	55	5
[illegible] Cantonments, ...	13	7	2	0	[illegible]	0	0	0	6	3	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]

half a mile of the Delhi branch of the Canals West of Jumna.

Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Average annual amount of canal irrigation.	Average annual amount of irrigated rice.	Proportion of tor irrigation.	Proportion of dand irrigation.	Detail of sizes of enlarged spleens.					
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
51	29	14	46	16	4000	1800	3600	400	1	4	12	45	11	73
55	55	45	50	14	1350	175	925	425	[illegible]	1	6	10	3	20
40	40	35	15	12	350	125	200	150	[illegible]	0	4	11	3	18
70	45	25	57	0	2200	500	1750	450	[illegible]	0	[illegible]	16	5	23
45	50	15	60	7	3000	750	2600	[illegible]	0	1	5	15	3	24
35	45	15	50	14	3130	420	2630	500	0	0	1	13	6	20
60	65	65	45	12	350	50	100	250	[illegible]	0	[illegible]	[illegible]	5	18
60	75	55	75	7	900	300	750	150	0	3	[illegible]	[illegible]	[illegible]	30
15	15	45	62	7	1450	350	1200	250	0	2	[illegible]	[illegible]	[illegible]	25
45	25	40	55	7	1710	300	1410	[illegible]	0	1	5	12	[illegible]	22
75	55	45	70	9	650	5	150	500	0	0	6	14	8	28
65	45	40	62	7	1100	50	600	500	2	3	7	10	[illegible]	25
65	40	25	70	5½	3000	400	2600	400	0	5	8	9	5	27
40	45	55	65	2½	600	150	350	250	1	3	7	13	1	25
35	60	50	75	4	5500	2500	4500	1000	1	2	5	20	2	30
65	65	50	67	5	550	20	475	75	0	0	5	15	7	27
75	25	80	77	5	1050	125	1000	50	0	3	5	18	5	31
55	40	45	67	6½	3000	800	2980	20	1	1	4	14	7	27
60	55	50	65	10	1000	225	1000	0	0	3	2	16	5	26
25	50	40	40	17	1200	10	1150	50	0	1	1	12	2	16
35	45	50	47	20	1000	175	995	5	0	1	2	10	6	19
52	32	29	18	40	—	—	—	—	0	0	3	17	9	29
51	45	41	58	11										
50	27	23	35	41					0	0	0	12	6	18
60	50	45	27	39					0	0	3	5	3	11

ABSTRACT of Medical Examinations of 28 *Irrigating villages distant half*

Villages.	Children of all Classes.		Adults.											
			Brahmins, Fukeers, &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Sitoundi, ...	25	15	9	2	10	0	6	0	5	1	3	1	3	0
Gagsecha, ...	33	7	6	0	20	1	6	0	5	0	3	0	4	1
Rair, ...	14	26	1	1	0	1	19	5	2	0	4	4	3	0
Moonuk, ...	27	13	7	0	2	1	11	1	4	3	3	1	4	3
Baul Jaton, ...	2	18	2	5	4	3	0	0	1	1	1	2	1	0
Baolee, ...	7	13	1	2	0	0	9	7	0	0	0	0	1	0
Burra Assun, ...	9	11	2	2	6	0	0	0	4	2	0	0	3	1
Chota Assun, ...	4	16	1	4	10	2	0	0	0	2	1	0	0	0
Noulta, ...	9	11	5	0	6	4	0	0	1	3	1	0	0	0
Duhur, ...	14	6	1	0	7	3	0	0	1	1	2	2	3	0
Hurtaree, ...	8	12	2	0	0	0	8	2	2	0	1	2	2	1
Brahmin Majra, ...	2	18	10	5	0	0	0	0	1	0	1	2	0	1
[illegible] Joundhun, ...	4	16	3	5	5	5	0	0	0	0	1	1	0	0
Karud, ...	3	17	2	1	7	2	0	0	0	0	3	3	0	2
Issrana, ...	8	12	1	0	5	4	0	0	2	1	2	3	1	1
Bhinjowl, ...	11	9	6	1	6	1	1	0	1	1	0	0	3	0
Dhindar, ...	9	11	3	1	0	0	7	2	1	1	1	1	2	1
Hoodana, ...	11	9	1	2	9	3	0	0	1	1	1	1	1	0
Kurreooree, ...	0	20	2	0	6	7	0	0	0	1	0	3	0	1
Chitana, ...	5	15	1	2	10	2	0	0	1	0	1	0	2	1
Bidhlaun, ...	5	15	1	1	5	3	0	0	1	3	2	1	2	1
Suelana, ...	6	14	2	1	10	0	0	0	2	1	1	1	1	1
Sissana, ...	12	[illegible]	4	0	7	1	0	0	2	2	3	0	0	1
Kandah, ...	9	11	2	2	7	2	0	0	0	3	3	1	0	0
Kutloopoor, ...	8	12	4	0	10	4	0	1	0	0	1	0	0	0
Burra Khera, ...	4	16	1	0	9	8	0	0	0	0	2	0	0	0
Badlee, ...	7	13	4	2	4	1	0	2	1	2	0	3	0	1
Wuzeerpoor, ...	3	17	1	1	6	6	0	0	0	1	0	3	0	2
	259	381	85	46	171	64	61	20	38	30	41	55	36	19

a mile or more from the Delhie branch of the Canals West of Jumna.

Totals.		Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Annual average amount of canal irrigation.			Average annual amount of irrigated rice.	Wells.	Detail of sizes of enlarged spleens.					
						TOR.	DAUL.	TOTAL.								
N	E	1844	1845	1846		Beegas.	Beegas.	Beegas.	Beegas.	Feet.	VL	L	M	O	S	Total.
36	4	52	42	20	24	400	1000	1400	150	25	0	0	1	9	9	19
38	2	35	17	10	11	1680	1320	3200	200	17	0	0	6	4	5	9
29	11	47	30	5	46	2400	500	2900	900	19	1	2	7	22	5	37
31	9	52	20	17	27	2100	400	2500	950	28	0	0	2	11	9	22
9	11	50	55	40	72	1200	1000	2200	600	0	0	2	7	14	6	29
11	9	75	60	40	55	2000	300	2300	1100	10	0	3	9	7	3	22
15	5	35	25	45	40	950	150	1100	200	7	0	1	3	5	7	16
12	8	70	65	45	60	550	50	600	80	8	0	1	4	11	8	24
13	7	65	55	45	45	2900	1200	4100	100	9	1	2	3	7	5	18
14	6	30	40	40	30	850	100	950	150	33	0	0	0	8	4	12
15	5	55	55	50	42	500	50	550	40	18	0	1	0	9	7	17
12	8	45	65	55	65	950	50	1000	10	16	1	0	4	20	1	26
9	11	55	40	45	67	1000	100	1100	50	20	0	0	6	12	9	27
12	8	55	65	30	62	1115	10	1125	5	30	0	0	3	13	9	25
11	9	50	40	55	52	2030	20	2050	75	0	1	0	2	13	5	21
17	3	50	75	40	30	720	5	725	40	14	0	0	2	9	1	12
14	6	55	40	60	42	375	100	475	20	17	0	0	1	13	3	17
13	7	65	50	45	40	700	800	1500	150	15	0	0	2	5	9	16
8	12	80	70	45	80	650	50	700	50	5	1	0	11	18	2	32
15	5	30	30	55	50	680	20	700	5	12	0	0	1	12	7	20
11	9	50	40	5	60	1980	20	2000	0	15	1	1	2	17	3	24
16	4	40	50	10	45	2000	0	2000	0	33	0	0	1	13	4	18
16	4	45	40	30	30	2750	50	2800	150	40	0	0	2	7	3	12
12	8	40	40	40	47	2595	5	2600	20	18	0	1	5	12	1	19
15	5	45	55	65	42	200	50	050	0	19	1	1	1	11	3	17
12	8	80	85	75	60	2800	0	2800	400	9	0	1	4	11	5	24
9	11	30	65	65	60	1200	0	1200	200	8	0	3	2	14	5	24
7	13	60	70	45	75	1140	10	1150	175	6	0	2	3	19	6	30
432	208	51	49	40	49					18						

ABSTRACT of Medical Examinations of 9 Irrigating villages situa…

Villages.	Children of all Classes.		Adults.													
			Brahmins, Fakeers, &c., &c.,		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c., &c.,*		*Menials.*		*Totals.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Singpoora, ...	11	9	3	1	8	3	0	0	1	0	1	0	2	1	15	5
Chichrana, ...	9	11	1	0	9	5	0	0	1	1	2	1	0	0	13	7
Bhyuswal, ...	10	10	4	0	9	0	0	0	0	1	3	2	1	1	16	4
Muhura, ...	9	11	1	0	9	4	0	0	1	1	2	0	1	1	14	6
Gohanna, ...	6	14	0	0	0	0	1	2	6	2	5	4	0	0	12	8
Muhmoodpoor, ...	7	13	0	0	11	6	0	0	1	0	0	0	2	0	14	6
Sumanka, ...	5	15	3	2	4	7	0	0	1	0	0	0	1	2	9	11
Korana, ...	12	8	5	0	9	1	0	0	0	2	2	1	0	0	16	4
Uhur, ...	9	11	4	2	7	1	0	0	0	1	2	0	2	1	15	5
	78	102	20	5	66	27	1	2	11	8	17	8	9	6	124	56

within half a mile of the Rohtuk branch of the Canals West of the Jumna.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*					
					Tor.	Daul.	Total.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
50	70	45	35	52	150	0	150	0	[illegible]	0	1	7	6	14
60	40	20	45	19	1750	50	1800	50	1	0	1	8	8	18
20	15	35	35	0	1400	100	1500	150	0	1	4	3	6	14
45	40	20	42	50	1050	150	1200	125	0	0	3	[illegible]	6	17
40	30	20	55	55	1550	50	1600	300	0	1	4	11	6	22
75	40	25	47	6	3740	10	3750	425	0	0	4	8	[illegible]	19
40	35	25	65	8	1185	15	1200	125	1	2	5	11	7	26
45	25	25	30	16	4420	200	4620	700	0	0	1	9	2	12
45	50	30	40	24	2050	300	2350	250	0	0	2	9	5	16
47	38	27	41	28										

ABSTRACT of Medical Examinations of Irrigating villages distant half

VILLAGES.	CHILDREN OF ALL CLASSES.		ADULTS.													
			Brahmins, Fukeers, &c., &c.,		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunias.*		*Artisans, &c.*		*Menials.*		*Total.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Rohtuk, ...	17	3	2	0	4	0	1	0	8	0	4	0	1	0	20	0
Chumaree, ...	10	10	0	1	9	3	0	0	3	0	2	0	2	0	16	4
Sanghee, ...	11	9	2	0	14	0	0	0	2	1	1	0	0	0	19	1
Burra Guhlowr, ..	13	7	2	1	12	2	0	0	1	0	0	0	1	1	16	4
Chota Guhlowr, ..	11	9	9	7	0	0	0	0	0	0	0	0	2	2	11	9
Matun, ...	9	11	1	0	10	3	0	0	3	0	1	0	1	1	16	4
	71	49	16	9	49	8	1	0	17	1	8	0	7	4	98	22

2

a mile or more from the Rohtuk branch of the Western Jumna Canals.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*					
					TOR.	DAUL.	TOTAL.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
5	20	40	7	72	750	0	750	0	0	0	0	0	3	3
45	65	45	35	50	650	100	750	0	0	0	0	6	8	[illegible]
65	45	15	25	28	3000	50	3050	150	0	0	2	5	3	10
35	30	25	27	46	745	5	750	20	0	0	0	4	7	11
30	25	5	45	46	500	0	500	10	0	0	1	11	6	16
25	20	30	37	47	1210	20	1230	150	0	0	5	9	1	15
34	34	27	29	48										

ABSTRACT of Medical Examinations of 24

Collectorate.	Villages.	Children of all Classes.		Adults.			
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*	
		N	E	N	E	N	E
Rohtuk, ..	Barouta, ...	16	4	4	3	7	1
	Gorur, ...	14	6	2	0	5	0
	Booketuh, ...	16	4	1	0	12	3
	Poohungee, ...	18	2	8	0	6	0
	Jusrana, ...	16	4	3	0	12	1
	Guewana, ...	14	6	6	0	6	0
	Kuclooee, ...	20	0	1	0	7	0
	Roorkhi, ...	17	3	2	0	4	0
	Moongan, ...	15	5	3	0	9	2
	Goyla, ...	20	0	1	0	14	0
	Doolhera, ...	19	1	2	0	10	0
	Matin, ...	19	1	2	1	9	1
	Assuecnda, ...	19	1	3	0	11	2
	Khoorawar, ...	17	3	3	1	8	2
	Kheree Sadh, ...	18	2	2	1	10	0
	Ruhundana, ...	18	2	2	0	7	0
	Jowlana, ...	18	2	5	0	7	
Hissar, ..	Burchuppur, ...	14	6	3	1	9	1
	Mohula, ...	15	5	2	0	9	1
	Bass.	20	0	3	0	10	1
	Bhatowl, ...	18	2	8	1	7	0
	Bugla.	17	3	1	0	16	0
	Jakhode, ...	18	2	1	0	9	0
	Myerr, ...	14	6	1	0	12	3
		410	70	69	8	216	18

unirrigated villages in the Delhi Territory.

Adults.										Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Detail of sizes of enlarged spleens.					
Mussulman cultivators.		Bunnias.		Artisans, &c.		Menials, &c.		Totals.												
N	E	N	E	N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.
0	0	0	0	2	1	2	0	15	5	40	40	30	22	21	0	0	1	5	3	9
0	0	3	0	8	0	2	0	20	0	20	30	15	15	60	0	0	0	4	2	6
0	0	2	0	0	1	1	0	16	4	50	30	55	20	56	0	0	1	4	3	8
0	0	1	0	1	0	4	0	20	0	45	40	40	5	82	0	0	0	1	1	2
0	0	0	1	1	1	1	0	17	3	40	30	40	17	80	0	0	0	4	3	7
2	1	1	0	1	0	3	0	19	1	40	30	30	17	90	0	0	0	3	4	7
0	0	3	0	5	0	4	0	20	0	25	15	5	0	97	0	0	0	0	0	0
0	0	5	0	7	0	1	1	19	1	20	55	40	10	95	0	0	0	3	1	4
1	0	2	0	0	1	1	1	16	4	30	20	60	22	80	0	0	0	7	2	9
0	0	1	0	2	0	2	0	20	0	10	15	30	0	45	0	0	0	0	0	0
0	0	1	0	5	0	2	0	20	0	30	5	15	2	57	0	0	0	1	0	1
0	0	1	0	4	0	2	0	18	2	35	20	25	7	65	0	0	0	1	2	3
0	0	0	0	1	0	3	0	18	2	35	30	35	7	65	0	0	1	0	2	3
0	0	2	0	2	0	2	0	17	3	60	50	35	15	77	0	0	0	2	4	6
0	0	1	0	4	0	2	0	19	1	25	20	20	7	85	0	0	0	1	2	3
4	0	0	0	6	0	1	0	20	0	40	25	5	5	122	0	0	0	0	2	2
0	0	3	0	3	0	2	0	20	0	60	35	40	5	123	0	0	0	0	2	2
0	0	1	0	2	1	2	0	17	3	30	50	40	22	132	0	0	0	6	3	9
0	0	0	0	1	1	5	1	17	3	65	55	25	20	0	0	0	0	6	2	8
0	0	2	0	2	0	1	1	18	2	50	40	35	5	132	0	0	0	0	2	2
0	0	0	0	2	0	2	0	19	1	70	60	30	7	118	0	0	0	1	2	3
0	0	0	0	2	0	1	0	20	0	80	25	10	7	81	0	0	0	3	0	3
0	0	4	*	4	0	2	*	20	0	60	15	10	5	101	0	0	0	2	0	2
0	0	1	*	1	0	1	1	16	4	70	30	15	25	102	0	0	1	6	3	10
7	1	34	1	66	6	49	5	441	39	43	32	28	11	85						

ABSTRACT of Medical Examinations of 21 towns and villages in the Protected

Situation.	Villages.	Children of all Classes.		Adults.					
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*	
		N	E	N	E	N	E	N	E
Situated near the Delhi Canal.	Dadoopoor, ...	10	9	0	0	7	2	0	0
	Boorreea, ...	13	7	4	0	2	0	1	1
	Moonda Majra, ...	14	6	3	1	5	3	0	0
	Damla, ...	10	10	1	0	9	1	3	0
	Kanjpoor, ...	6	14	1	0	8	5	0	0
	Radowr, ...	8	12	3	0	0	0	0	0
	Zynpoor, ...	4	16	0	2	3	1	3	1
	Indree, ...	5	15	4	1	3	1	1	0
	Gooda, ...	5	15	3	2	2	1	2	3
	Khera, ...	8	12	2	2	8	3	2	0
	Beebeepoor, ...	8	12	1	1	12	2	0	0
	Dharrur, ...	8	12	1	0	0	0	9	2
		99	140	23	9	54	19	21	7
Unconnected with the Delhi Canal.	Loodiana, ...	12	8	1	0	0	1	0	0
	Umballa, ...	19	1	0	0	4	0	5	2
	Khooda, ...	10	10	6	0	2	0	2	2
	Mullana, ...	11	9	5	2	5	0	3	0
	Mustafabad, ...	9	11	5	0	0	0	2	1
	Tejlee, ...	11	6	4	1	9	0	0	0
	Bun, ...	11	9	1	1	5	1	0	0
	Ladwa, ...	12	8	1	1	1	1	1	0
	Pinjokra, ...	7	13	0	0	7	2	0	1
		105	75	23	5	33	6	13	6

Sikh States, of which 12 *are connected, and* 9 *unconnected with the Delhi Canal.*

Adults.								Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Detail of sizes of enlarged spleens.					
Bunnias.		*Artisans, &c.*		*Menials, &c.*		*Totals.*												
N	E	N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.
2	1	5	1	1	0	15	4	45	55	40	34	12	0	1	2	6	4	13
6	1	3	0	2	0	18	2	30	50	20	22	0	0	1	0	6	2	9
1	2	3	1	1	0	13	7	60	65	20	32	0	0	0	0	10	3	13
4	0	1	0	1	0	19	1	35	70	30	27	0	0	0	0	4	7	11
1	1	2	2	0	0	12	8	60	60	40	55	0	0	2	3	13	4	22
7	5	3	0	0	2	15	7	35	70	25	47	24	0	1	1	12	5	19
3	2	0	3	1	1	10	10	55	55	20	65	0	1	1	1	19	4	26
2	3	1	4	0	0	11	9	60	40	35	60	15	1	2	4	13	4	24
1	0	3	3	0	0	11	9	30	30	20	60	23	0	1	3	14	6	24
1	2	1	2	2	0	11	9	65	45	25	62	8	0	0	1	10	10	21
0	0	3	0	1	0	17	3	40	40	30	37	11	0	0	1	9	5	15
5	0	1	0	2	0	18	2	50	40	10	35	20	0	0	0	11	3	14
33	17	26	16	11	3	168	71	47	52	26	44							
4	0	14	0	0	0	19	1	20	70	30	22	0						
6	1	2	0	0	0	17	3	25	60	40	10	0						
5	3	0	0	0	0	15	5	30	25	10	37	0						
3	1	1	0	0	0	17	3	65	65	30	30	0						
8	2	1	1	0	0	16	4	55	85	25	37	0						
1	0	3	0	2	0	19	1	30	60	35	17	0	0	0	0	4	3	7
2	1	6	1	2	0	16	4	65	55	35	32	0	0	0	2	8	3	13
4	2	3	1	4	1	14	6	40	70	35	35	0	0	2	1	7	4	14
0	0	3	1	6	0	16	4	60	55	30	42	21	0	0	2	11	4	17
35	10	33	4	14	1	149	31	43	61	30	29							

ABSTRACT of Medical Examinations of 34 villages.

VILLAGES.	CHILDREN OF ALL CLASSES.		ADULTS.					
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*	
	N	E	N	E	N	E	N	E
Gungoh, ...	14	6	1	0	6	0	3	1
Beera Kheree, ...	16	4	2	1	12	1	1	0
Umbehta, ...	14	6	1	0	4	0	2	0
Kheree, ...	15	5	2	0	6	0	3	0
Sidhowli, ...	17	3	0	0	17	1	0	0
Pilkhuni, ...	16	3	1	0	8	1	0	0
Jajwa, ...	11	9	3	0	5	0	3	0
Jugehta, ...	13	7	1	1	5	0	0	0
Chitowra, ...	20	0	0	0	2	0	[illegible]	0
Tajpoor, ...	20	0	7	0	5	0	[illegible]	0
Khatowli, ...	16	4	1	0	5	0	0	0
Muhmoodpoor Lahora, ..	18	2	0	0	9	0	2	0
Sutheree, ...	17	3	4	0	4	0	1	0
Sulawah, ...	19	1	2	0	8	0	1	0
Jowalagurh, ...	19	1	2	0	5	0	0	0
Sirdhana, ...	36	4	5	0	6	0	0	0
Nanoon, ...	19	1	0	0	0	0	14	1
Bhalsowna, ...	16	4	4	0	16	0	0	0
Doongur, ...	26	0	3	0	9	0	0	0
Bhola, ...	19	1	6	0	1	0	1	0
Peeplee Adureespoor, ...	19	1	5	1	8	0	3	0
Meerut Cantonment, ...	77	3	1	0	2	0	3	0
Bhoorbural, ...	18	2	6	0	8	0	0	0
Begumabad, ...	19	1	3	2	2	0	1	1
Seekree, ...	18	2	3	0	16	0	0	0
Dohaee, ...	20	0	4	0	8	0	0	0
Kurkurree, ...	20	0	3	0	14	0	0	0
Bagouth, ...	18	2	1	0	17	0	0	0
Bhyrapoor, ...	19	1	7	0	[illegible]	0	0	0
Powyss, ...	15	5	4	0	15	0	0	0
Sunowli, ...	19	1	0	0	16	1	0	0
Sherpoor, ...	17	3	0	0	13	0	1	0
Solana, ...	14	6	4	0	[illegible]	0	0	0
Mokundpoor, ...	15	5	1	0	13	0	2	0
	663	96	87	5	277	4	5[illegible]	3

&c., practising Well Irrigation in the Northern Doaab.

Adults. Bunnias. N	E	Artisans, &c. N	E	Menials, &c. N	E	Totals. N	E	Per centage of adults having suffered from fever in 1844	1845	1846	Per centage of enlarged spleens.	Depth of water from the surface of ground. Feet.	Detail of sizes of enlarged spleens. VL	L	M	O	S	Total.
1	0	4	0	4	0	19	1	70	55	40	17	16	0	0	0	2	5	7
0	0	3	0	0	0	18	2	55	55	40	15	20	0	0	0	1	5	6
7	0	4	0	2	0	20	0	60	35	10	15	11	0	0	0	4	2	6
5	1	5	1	3	0	18	2	25	45	55	17	15	0	0	0	5	2	7
0	0	2	0	0	0	19	1	25	15	5	10	14	0	0	0	1	3	4
0	0	1	0	0	0	10	1	36	45	36	13	12	0	0	0	2	2	4
5	1	3	0	0	0	19	1	65	7	35	25	14	0	0	0	3	7	10
4	0	5	0	4	0	19	1	20	36	15	20	11	0	0	0	5	3	8
2	0	7	0	1	0	20	0	30	46	10	0	30	0	0	0	0	0	0
0	0	1	0	4	0	20	0	30	10	0	0	19	0	0	0	0	0	0
10	0	3	0	1	0	20	1	60	15	10	10	20	0	0	0	1	3	4
5	0	1	0	3	0	20	1	35	25	30	5	20	0	0	0	0	2	2
3	0	7	0	1	0	20	1	55	15	20	7	22	0	0	0	0	3	3
4	0	4	1	0	0	19	[illegible]	20	25	5	5	20	0	0	0	1	1	2
4	0	6	0	1	0	20	1	40	56	30	2	25	0	0	0	0	1	1
13	0	12	0	4	0	40	0	32	35	17	5	20	0	0	0	2	[illegible]	4
3	0	0	0	1	1	18	2	35	35	35	7	17	0	0	0	2	1	3
0	0	3	0	3	0	20	0	35	30	5	10	24	0	0	0	0	4	4
1	0	4	0	3	0	20	1	25	20	20	0	35	0	0	0	0	0	0
3	0	5	0	4	0	20	0	[illegible]	25	10	2	22	0	0	0	1	0	1
0	0	1	0	2	0	19	1	25	5	10	5	25	0	0	1	1	0	2
33	0	30	0	11	0	80	0	29	29	16	2	12	0	0	0	2	1	3
0	2	1	0	2	1	17	3	35	25	30	12	19	0	0	0	2	3	5
4	0	5	0	2	0	17	3	35	30	25	10	27	0	0	0	0	4	4
0	0	0	0	1	0	20	0	0	0	0	5	29	0	0	1	0	1	2
4	0	1	0	3	0	20	0	35	40	20	0	32	0	0	0	0	0	0
1	0	0	0	2	0	20	0	50	30	10	0	35	0	0	0	0	0	0
[illegible]	0	0	0	2	0	20	0	20	20	20	5	36	0	0	0	0	2	2
0	0	0	0	1	0	20	0	35	10	25	2	38	0	0	0	0	1	1
0	0	0	0	1	0	20	0	20	10	10	12	44	0	0	0	3	2	5
0	0	1	0	2	0	19	1	35	15	10	5	35	0	0	0	0	2	2
1	0	0	0	5	0	20	0	55	30	10	7	38	0	0	0	1	2	3
0	0	0	0	3	1	19	1	45	50	10	17	36	0	0	0	1	6	7
1	1	1	0	1	0	19	1	45	50	30	15	33	0	0	0	3	3	6
114	5	122	2	77	3	72[illegible]	[illegible]	37	31	20	8	24						

ABSTRACT of Medical Examinations of 20 unirrigated villages of which 5 are

Situation.	Villages.	Children of all Classes.		Adults.							
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*	
		N	E	N	E	N	E	N	E	N	E
Ganges Khadir, ...	Kunkhul, ...	14	6	8	1	1	1	0	0	4	0
	Jowalapoor, ..	19	1	6	1	0	0	0	0	3	0
	Bahadurabad, ..	17	3	1	0	3	2	2	0	4	1
	Saatul Shah, ..	11	9	4	1	4	5	0	0	0	0
	Budheree, ...	17	3	5	0	0	0	8	2	1	0
		78	22	24	3	8	8	10	2	12	1
Rangur or high land of the Dooab, ..	Punniala, ...	15	5	4	0	8	1	1	0	1	0
	Roorkhi, ...	17	3	3	0	3	0	5	0	1	1
	Manglour, ...	30	0	4	0	2	0	8	1	5	[illegible]
	Hurriabas, ...	18	2	0	0	15	0	0	0	0	0
	Liburheree, ...	20	0	5	0	8	0	0	0	1	0
	Muhmoodpoor, ..	19	1	7	0	11	0	0	0	0	0
	Poor, ...	19	1	2	0	1	0	8	0	0	0
	Togulpoor, ...	19	1	1	0	3	0	0	0	5	0
	Khai Khera, ..	20	0	3	0	11	1	0	0	1	0
	Nirgajni, ...	20	0	1	0	16	0	0	0	0	0
	Jelra, ...	20	0	2	0	4	0	0	0	5	0
	Bhopa, ...	20	0	5	0	6	0	0	0	1	0
	Yusufpoor, ...	20	0	2	0	10	0	2	0	1	0
	Jaolee, ...	20	0	3	0	1	0	10	0	1	1
	Kowal, ...	19	1	2	0	0	0	4	0	6	1
		296	14	44	0	99	2	38	1	[illegible]	[illegible]

in the N. W. Khadir of the Ganges, and 15 are situated on the high land of the Dooab.

Adults.						Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water from the surface of ground.	Detail of sizes of enlarged spleens.					
Artisans, &c.		Menials, &c.		Totals.												
N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.
4	0	0	1	17	3	30	35	30	22	18	0	[illegible]	1	4	4	9
8	0	2	0	19	1	35	30	30	5	56	0	0	0	0	2	2
2	0	4	1	16	4	25	40	35	17	34	0	0	1	2	4	7
1	3	1	1	10	10	60	60	20	47	9	1	[illegible]	3	9	6	[illegible]
2	0	2	0	18	2	55	45	25	12	9	0	[illegible]	0	4	1	5
17	[illegible]	9	3	80	20	41	42	28	21	25						
3	0	2	0	19	1	60	60	20	15	18	0	0	0	3	1	4
3	0	5	0	20	0	25	45	25	7	28	0	0	0	3	0	3
6	0	4	0	29	1	32	37	22	2	45	0	0	0	0	1	1
3	0	2	0	20	0	35	5	10	5	15	0	0	0	0	2	2
4	0	2	0	20	0	35	20	5	0	49	0	0	0	0	0	0
0	0	2	0	20	0	5	30	5	2	58	0	0	0	1	[illegible]	1
7	0	2	0	20	0	35	25	15	2	0	0	0	0	1	0	1
9	0	2	0	20	0	45	50	25	2	62	0	0	0	0	1	1
1	0	2	1	18	2	30	35	10	5	62	0	0	1	0	1	2
1	0	2	0	20	0	25	20	5	0	73	0	0	0	0	[illegible]	0
5	0	1	0	20	0	55	35	15	0	58	0	0	0	0	[illegible]	0
5	0	3	0	20	0	30	15	0	0	54	0	0	0	0	[illegible]	0
2	0	3	0	20	0	15	30	5	0	52	0	0	0	0	[illegible]	[illegible]
2	0	2	0	19	1	20	30	20	2	40	0	0	0	1	[illegible]	1
5	0	3	0	19	1	30	10	10	5	29	0	0	0	1	1	2
56	0	37	1	304	6	32	30	13	3	46						

ABSTRACT of Medical Examinations of 19 *Irrigating villages situated within*

Villages.	Children of all Classes.		Adults.											
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials, &c. &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Selimpoor, ...	5	15	1	2	11	6	0	0	0	0	0	0	0	0
Behtuh, ...	9	11	2	1	4	1	7	1	0	1	2	1	0	0
Sukulpoor, ...	17	3	0	0	18	1	0	0	0	0	1	0	0	0
Surrowli, ...	18	2	3	0	15	1	0	0	0	0	0	1	0	0
Duggurpoor, ...	15	5	1	1	11	0	0	0	3	0	2	0	2	0
Binnapoor, ...	20	0	0	0	11	1	1	0	0	0	4	0	3	0
Rutowl, ...	15	5	0	0	0	0	15	1	0	0	1	0	1	2
Moobarikpoor, ...	16	4	5	2	10	1	0	0	0	0	0	0	2	0
Muhrumpoor, ...	18	2	1	0	16	1	0	0	0	0	0	0	2	0
Deola, ...	13	7	2	0	4	2	5	1	2	1	1	0	2	0
Busode, ...	14	6	0	0	0	0	15	2	0	0	1	0	2	0
Nugla, ...	15	5	3	1	8	1	0	0	0	0	2	3	1	1
Ulawalpoor, ...	11	9	1	0	7	5	0	0	1	2	2	0	1	1
Barote, ...	11	9	1	1	6	2	0	0	3	0	2	1	3	1
Romalla, ...	12	8	2	3	7	2	0	1	0	0	1	0	3	1
Kukripoor, ...	12	8	1	0	12	2	0	1	0	0	1	1	1	1
Nalle, ...	10	10	4	0	11	0	0	0	1	0	2	0	1	1
Kandla, ...	13	7	1	0	8	2	4	1	2	0	1	0	1	0
Khundraoli, ...	13	7	0	1	14	2	0	0	0	0	0	1	2	0
. .	257	123	28	12	173	30	47	8	12	4	23	8	27	8

half a mile of the Suharunpore or Eastern Jum[illegible] Canal, in the Southern Division.

Adults. Totals.		Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water from the surface of ground.	Detail of sizes of enlarged spleens.						Annual [illegible]ge amount of canal irrigation. Tor.	Daul.	Total.	Average annual amount of irrigated rice.
N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.	Beegas.	Beegas.	Beegas.	Beegas.
12	8	50	50	45	57	7	0	2	1	12	8	23	47	0	47	10
15	5	40	30	30	40	19	0	0	2	10	4	16	365	19	384	26
19	1	60	35	15	10	32	0	0	0	3	1	4	216	37	253	0
18	2	50	45	25	10	24	0	0	1	0	3	4	217	284	501	4
19	1	45	40	10	1[illegible]	30	0	0	1	2	3	6	342	88	430	16
19	1	65	40	5	2	32	0	0	0	0	1	1	12	25	37	0
17	3	0	0	0	20	33	0	0	0	6	2	8	633	338	971	22
17	3	40	40	0	17	33	0	0	0	4	3	7	63	504	567	23
19	1	40	60	10	7	37	0	0	0	2	1	3	103	155	258	18
16	4	70	60	20	27	24	0	0	1	5	5	11	673	844	1516	41
18	2	65	50	25	20	24	0	0	0	4	4	8	209	622	831	22
14	6	60	50	10	27	21	0	1	0	4	6	11	59	131	190	21
12	8	25	30	5	42	18	0	0	4	7	6	17	757	6	763	76
15	5	65	55	20	35	26	0	1	3	8	2	14	970	819	1789	155
13	7	50	40	25	37	21	0	0	2	5	8	15	2366	50	2416	320
15	5	45	15	5	32	27	0	0	0	5	8	13	1491	6	1497	209
19	1	45	15	10	27	21	0	0	3	5	3	11	1062	489	1551	182
17	3	30	20	15	25	23	0	0	0	4	6	10	2314	1591	3905	268
16	4	35	40	25	27	14	0	0	1	3	7	11	1898	18	2015	107
310	70	48	40	17	25	24										

ABSTRACT of Medical Examinations of 12 *Irrigating villages more than half*

Villages.	Children of all Classes.		Adults. Brahmins, Fakeers, &c. &c.		Hindoo cultivators.		Mussulman cultivators.		Bunnias.		Artisans, &c.		Menials, &c. &c.	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Gunowli, ...	20	0	6	0	18	1	0	0	0	0	0	0	1	0
Meethlee, ...	18	2	2	0	14	1	0	0	1	0	0	0	2	0
Jounmana, ...	11	9	4	0	12	2	0	0	0	0	0	0	0	2
Dukana, ...	10	10	2	1	8	1	0	0	2	0	3	0	2	1
Loharra, ...	12	8	2	0	11	0	0	0	1	0	4	0	2	0
Bazeedpoor, ...	15	5	1	0	9	0	0	0	0	0	5	0	5	0
Bujwarra, ...	17	3	4	0	8	1	0	0	2	0	2	0	1	2
Fazilpoor, ...	12	8	2	0	12	1	0	0	0	0	3	0	2	0
Kumalla, ...	18	2	3	0	12	1	0	0	1	0	0	0	3	0
Ramnuggur, ...	16	4	7	1	4	0	0	0	0	0	6	0	2	0
Tetronda, ...	15	5	0	0	12	3	0	0	1	0	0	0	3	1
Soontee, ...	10	10	3	0	6	2	0	1	0	0	5	1	2	0
	174	66	30	2	126	13	0	1	8	0	28	1	25	6

a mile distant from the Suharunpoor or Eastern Jumna Canal, in the S. Division.

Adults. Totals. N	E	Per centage of adults having suffered from fever in 1844	1845	1846	Per centage of enlarged spleens.	Depth of water from the surface of ground. Feet.	Detail of sizes of enlarged spleens. VL	L	M	O	S	Total.	Annual average amount of canal irrigation. Tor. Beegas.	Daul. Beegas.	Total. Beegas.	Average annual amount of irrigated rice. Beegas.
19	1	60	15	10	2	27	0	0	0	1	0	1	278	27	305	0
19	1	50	40	15	7	32	0	0	0	3	0	3	172	253	425	33
16	4	30	15	15	32	29	0	0	1	8	4	13	89	202	291	4
17	3	50	50	30	32	30	0	0	1	10	2	13	136	228	364	29
20	0	30	30	5	20	35	0	0	0	5	3	8	224	26	250	19
20	0	25	15	0	12	36	0	0	0	3	2	5	25	55	80	0
17	3	45	30	10	15	43	0	0	0	2	4	6	179	281	460	15
19	1	70	20	5	22	36	0	0	1	5	3	9	339	122	460	41
19	1	30	25	25	7	43	0	0	0	1	2	3	199	0	199	12
19	1	60	25	20	12	34	0	0	0	2	3	5	64	0	64	4
16	4	50	60	15	22	33	0	0	0	4	5	9	924	12	936	56
16	4	60	30	20	35	28	0	0	0	3	11	14	518	3	521	82
217	23	47	30	14	18	34										

ABSTRACT of Medical Examinations of 18 *villages, Irrigating from the are within half a mile of the Canal,*

Situation.	Villages.	Children of all Classes.		Adults. Brahmins, Fakeers, &c.		Hindoo cultivators.		Musulman cultivators.		Bunnias.		Artisans, &c.		Menials, &c.		Totals.	
		N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Within half a mile of Canal.	Bhynswal, ...	4	16	1	2	7	4	0	0	1	2	1	0	2	9	12	[illegible]
	Khyle, ...	2	15	2	6	3	7	0	0	1	0	0	2	4	1	10	10
	Kheree Gudhai, ...	3	17	1	0	8	3	1	0	1	1	1	3	1	1	13	8
	Maunkpoor, ...	6	14	2	3	7	0	1	0	0	0	1	4	2	0	13	7
	Berkheree, ...	6	14	1	0	4	0	0	0	0	1	1	0	[illegible]	[illegible]	11	3
	Poojna, ...	6	14	2	0	5	4	0	0	4	1	3	1	3	0	14	6
	Munowra, ...	5	15	1	0	10	3	0	0	0	0	2	0	3	1	16	4
	Abba, ...	6	11	1	1	6	6	6	3	0	4	1	1	1	1	9	11
	Amtuhow, ...	1	19	0	0	7	7	0	0	1	6	2	1	2	0	12	5
		39	141	11	6	55	28	7	4	5	9	12	12	26	12	109	71
Distant more than ½ a mile from Canal.	Mundait, ...	2	18	1	0	7	7	0	0	0	0	0	0	1	1	12	[illegible]
	Mutheralee, ...	8	12	2	0	11	2	0	0	1	0	1	1	2	0	17	3
	Paquree, ...	1	19	1	0	6	0	9	2	0	0	4	0	1	1	12	[illegible]
	Terbrooh, ...	8	12	3	0	5	1	1	0	2	3	3	0	0	2	15	[illegible]
	Teekrowl, ...	4	16	2	0	16	2	0	0	1	1	1	1	2	0	16	3
	Hingowli, ...	5	15	2	1	[illegible]	3	0	0	0	[illegible]	1	1	4	1	12	8
	Dhekalay, ...	8	12	1	1	5	2	2	0	0	[illegible]	1	0	4	0	17	3
	Sejorra, ...	3	15	0	0	2	1	10	0	0	[illegible]	2	1	2	3	16	4
	Kanjorke, ...	15	5	0	1	0	0	11	2	0	0	1	0	5	0	17	3
		53	126	11	3	56	14	33	9	4	7	11	4	21	7	134	46

Saharunpore or Eastern Jumna Canal, in the centre Division, of which 9 villages and 9 villages are at a greater distance.

Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Detail of sizes of enlarged spleens.						Annual average amount of canal irrigation.			Annual average amount of irrigated rice.
											Tor.	Daul.	Total.	
1844	1845	1846		Feet.	VL	L	M	O	S	Totals.	Beegas.	Beegas.	Beegas.	Beegas.
40	35	30	60	7	0	0	2	12	10	21	2168	[illegible]	2397	542
60	45	40	70	6	0	2	4	15	4	28	779	58	836	249
85	65	15	62	3	0	0	9	15	8	25	485	5	499	143
75	65	35	52	8	0	0	1	12	8	21	371	87	458	130
50	65	46	57	5	0	1	5	7	10	23	230	65	294	143
50	45	17	50	9	0	0	2	8	10	20	242	57	299	74
70	50	30	47	9	0	0	0	9	10	19	370	23	393	104
50	40	5	62	11	0	2	5	10	8	25	455	32	487	159
90	80	6	68	7	0	0	5	14	8	27	491	116	607	205
63	54	31	59	8										
55	35	2	65	20	0	0	6	16	4	26	503	141	644	121
50	40	25	37	11	0	1	2	5	6	15	38	17	55	0
55	65	35	67	11	0	0	5	12	10	27	592	20	612	252
75	44	25	42	16	0	0	3	1	10	17	600	13	613	48
55	60	30	50	11	0	1	3	8	8	20	1530	80	1610	523
60	55	35	37	17	0	0	1	10	12	23	339	55	394	0
55	55	26	37	18	0	0	0	5	10	15	117	0	117	75
50	65	50	52	11	0	0	1	11	9	21	496	143	639	201
70	60	35	20	12	0	0	0	3	5	[illegible]	160	108	268	78
60	53	33	47	14										

ABSTRACT of Medical Examinations of 15 villages, &c., under various circum-

Circumstances.	Villages.	Children of all Classes.		Adults.									
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunniahs.*		*Artisans, &c. &c.*	
		N	E	N	E	N	E	N	E	N	E	N	E
Irrigating within half a mile of Canal.	Reeree,	7	13	3	0	8	3	0	0	1	0	3	0
	Ratnakhera,	15	7	0	1	5	2	0	0	6	0	7	1
	Manickmhow,	12	8	4	0	5	1	0	0	1	0	3	2
	Rundole,	17	3	1	0	4	1	0	0	2	0	8	1
	Kulsea,	19	1	3	0	8	0	0	0	3	0	0	0
	Raipoor,	19	1	5	0	4	0	2	0	1	0	5	0
		87	33	16	1	34	7	2	0	8	0	26	4
Irrigating distant more than half a mile from Canal.	Nowabas,	11	9	0	0	13	1	0	0	1	1	2	0
	Hurpal,	12	8	0	0	0	0	5	1	5	1	6	0
	Subujwa,	17	3	4	0	10	0	0	0	1	0	6	0
	Beetia,	15	5	2	1	7	2	0	0	0	1	1	0
	Suharunpore,	31	29	4	1	7	6	5	2	8	1	13	4
	Behut,	18	2	0	0	2	1	7	0	4	1	[illegible]	0
		104	56	10	2	39	10	17	3	19	5	[illegible]	4
Unirrigated near head of Canal.	Nyashuhur,	19	1	1	0	6	0	1	0	0	0	8	0
	Tanda,	20	0	0	0	6	0	0	0	0	0	2	0
	Fyzabad,	15	5	2	0	6	0	0	0	2	0	3	1
		54	6	3	0	18	0	1	0	2	0	14	1

stances in the Northern Division of the Suharunpore or Eastern Jumna Canal.

Adults.																		
Menials, &c., &c.		*Totals.*		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Depth of water from surface of ground.*	*Detail of sizes of enlarged spleens.*						*Annual average amnt. of canal irrigation.*			*Average annual amount of Irrigated Rice.*
															Tor.	Daul.	Total.	
N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.	Beegas.	Beegas.	Beegas.	Beegas.
2	0	17	3	55	65	25	40	3	0	0	1	6	9	16	436	72	508	56
3	1	15	5	40	55	25	30	9	0	0	0	5	7	12	82	10	92	15
3	1	16	4	25	35	5	30	12	0	0	0	6	6	12	403	123	526	148
3	0	18	2	10	50	55	12	7	0	0	1	2	2	5	643	86	729	413
5	1	19	1	10	15	10	5	8	0	0	0	1	1	2	0	0	0	0
3	0	20	0	20	15	45	2	0	0	0	0	1	0	1	52	3	55	0
19	3	105	15	27	39	27	20	8	0	0								
2	0	18	2	55	40	40	27	9	0	0	0	3	8	11	272	180	452	117
2	0	18	2	40	70	30	25	16	0	0	1	4	5	10	41	18	59	6
4	1	19	1	10	25	10	10	11	0	0	0	0	4	4	99	153	262	14
3	0	16	4	60	60	20	22	15	0	0	0	3	6	9	3	0	3	0
7	2	44	16	33	45	40	38	8	0	[illegible]	5	20	17	15	0	0	0	0
2	0	18	2	25	40	40	10	18	0	0	0	1	3	4	41	4	45	0
20	3	133	27	37	47	30	22	13	0	0	0							
4	0	20	0	25	30	10	2	0	0	0	0	0	1	1	0	0	0	0
11	0	20	0	35	40	30	0	0	0	0	0	0	0	0	0	0	0	0
6	0	19	1	45	60	40	15	0	0	0	0	3	3	6	0	0	0	0
21	0	59	1	35	43	27	6											

Summary — *General Abstract*

Irrigated from the *Western Jumna Canals.* —	Delhi Branch,	....	....	....
	Rohtuk Branch,	....	....	....
	Bootana Branch,	....	....	....
	Hansi Branch,	....	....	....
Irrigated from the *Eastern Jumna Canals.*	Northern Division,	....	....	....
	Centre Division,	....	....	....
	Southern Division,	....	....	....
Irrigated from *wells* in the high land of the Dooab,		....	....	....
Unirrigated. —	Sikh States,	....	....	....
	Delhi Territory,	....	....	....
	Northern Doab,	....	....	....
	Naturally malarious localities,		....	....

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of Medical Examinations.

	Per centage of enlarged spleens.	*Per centage of adults having suffered from fever in*			*Average depth of water from surface of ground*
	Adults and Children of all Classes.	1844	1845	1846	Feet.
Within half [redacted] mile of the Canal, ..	58	51	45	41	11
Distant more than half a mile, ..	49	51	49	40	18
Within half [redacted] mile of the Canal, ..	[redacted]	47	38	27	28
Distant [redacted]re than half [redacted] mile, ..	29	34	34	27	48
Distant [redacted]re than half a mile, ..	16	41	36	22	102
Within half a mile of the Canal, ..	39	50	41	22	92
Distant [redacted] than half a mile, ..	13	40	31	16	118
Within half a mile of the Canal, ..	20	27	39	27	8
Distant more than half a mile, ..	22	37	47	30	13
Within half a mile of the Canal, ..	59	63	54	31	8
Distant more than half [redacted] mile, ..	47	60	53	33	14
Within half a mile of the Canal, ..	25	48	40	17	24
Distant [redacted]re than half a mile, ..	18	47	30	14	34
.. ..	8	37	31	20	24
Connected with the Canal, ..	44	47	52	26	0
Unconnected with the Canal, ..	29	43	61	30	0
Unconnected with the Canal, ..	11	32	28	11	88
High or Bangor land, ..	3	32	30	13	46
Ganges Khadir, ...	21	41	42	28	25
Near head of Eastern Jumna Canal,	[redacted]	35	43	27	0
Nujufgurh Jheels, ...	44	42	59	57	15
Valleys of Jumna and Hindun, ...	34	46	42	31	14

APPENDIX E.

Abstract of the Medical Examinations, affording the principle data for the fore-going Report.

The recorded numbers of natural and enlarged spleens may be received as representing authentic facts.

The per centage of sufferers from fever in the several years is deduced from the records of oral testimony collected by the Committee, and may possibly in many instances be not strictly correct. It is hoped however, that in the general averages will be found an approximation to the truth, and the means of comparing with tolerable certainty the salubrity of different years.

The depths of water from the surface of ground were ascertained by actual measurement and the information regarding the extent and nature of Canal irrigation are furnished by the Superintendents of the respective Canals.

Explanation of the headings, used in the subjoined Abstracts.

N. Natural or healthy spleens.

E. Enlarged spleens.

VL. L. &c. Sizes of spleens as in Appendix C.

Tor irrigation is where the water flows naturally over the soil as distinguished from

Daul irrigation, where the water is artificially raised to the level of the ground.

The areas of irrigated land are stated in beegas of 3,025 square yards, 640 beegas being equal to 1 square mile.

APPENDIX F.

Measures connected with the execution and management of the proposed Ganges Canal, alluded to in paragraph 15 of the Report, as deserving the attention of Government.

The Committee would recommend as follows :—

1st That the Ganges Canal be kept as much as possible within soil, i. e. that its ordinary surface level should be below that of the country.

2nd. That earth wanted to complete embankments, be never obtained from excavations made outside of the canal, except in such localities as will readily admit of drainage.

3rd. That the canal and its branches be taken as much as possible along the water-shed line of the country, so as not to interfere with drainage, and in all cases where such interference may be unavoidable, that the executive office be instructed to provide otherwise for the drainage.

4th. That masonry drains be constructed under Rajbuhas or Bridge Ramps, whenever these cross the drainage of the country.

5th. That no private water-courses be allowed, but that irrigation be practised exclusively from Rajbuhas or main water-courses.

6th. That irrigation be prohibited within five miles of a military station and within one or two miles of large native towns.

7th. That in clearing embankments, the grass, weeds, &c., be not suffered to rot on the ground, but that they be burned as soon as possible after they are cut.

8th That irrigation be altogether prohibited in localities which appear naturally to possess a malarious character.

The Committee are aware that the adoption of the measures above recommended would involve an expense not contemplated in the original estimates for the Ganges Canal.

(Signed) W. E. BAKER, MAJOR, *Engineers and President.*

(Signed) T. E. DEMPSTER, SURGEON, *Member.*

APPENDIX G.

Comparative Abstract shewing the Ratio of Population to area in certain irrigated and unirrigated districts of the North Western Provinces.

Detail of irrigation, &c.	*Name of Collectorate.*	*Number of Villages.*	*Aggregate area in Beegas of 3025 square yards.*	*Aggregate Population.*	*Population per square mile.*	*Average Population per square mile.*
Irrigated from Canals.	Paniput, ..	96	329,947	74,360	231	
	Delhie, ..	49	101,472	33 754	341	
	Rohtuk, ..	52	221,262	60 007	278	317
	Hissar, ..	35	224,563	11,465.	54	
	Mozuffernuggur, ..	15	23,195	15,4[illegible]6	680	
Irrigated from Wells.	Mozuffernuggur, ..	100	118,556	57,665	497	0
Unirrigated.	Paniput. .	29	61.194	12,320	206	
	Rohtuk, ..	61	373.531	59 895	164	165
	Hissar, ..	40	343.207	16,014	51	
	Mozuffernuggur. ..	73	95.416	22 180	238	

This Abstract is referred to in paragraph 19 of the Report.

(Signed) W. E. BAKER, Major,
President.

(Signed) T. E. DEMPSTER, Surgeon,
Member.

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APPENDIX H.

Abstract of some of the principle facts recorded in the report of a Medical Committee appointed in the Government of Madras to investigate the causes of an epidemic fever which prevailed in the Provinces of Coimbatore, Dindigul, Madura and Tinnevelly, during the years 1809, 1810 *and* 1811.

The soil of Coimbatore is in general dry, but there is no want of extensive tanks. In the vicinity of the Hills is much low marshy ground, and many villages in such situations are proverbially unhealthy. On the whole the Coimbatore country may be called healthy in common years.

Dindigul is a mountainous and woody country, encompassed by high lands, and more or less covered by Jungle of prodigious height. Climate stated to be proverbially healthy in common years.

Madura is a more open and less mountainous country than Dindigul; it is hotter in the hot season and not quite so cold in the months of December and January. The climate of this district, in common seasons, cannot by any means be considered unhealthy, although the fort has been so for several years, and before the epidemic prevailed. Like most mountainous countries in the torrid zone, Madura has situations where fever never fails, at certain seasons, to be endemic; but the disease does not generally spread beyond these localities. There are some villages close to, and amongst the Hills, lying in the most western parts of the province, in which, in the months of March and April, no man can pass a single night without suffering an attack of fever soon after. Both the houses and clothing of the inhabitants are of a very inferior description.

Tinnevelly is considerably lower than any of the other provinces in which the epidemic prevailed; it may, in the strictest sense, be called an open country; as few Hills are to be found in it, and those are isolated or detached. It contains several waste and jungly tracts, especially towards the east. There are also, here and there, extensive low and marshy lands in the vicinity of the mountains, &c. Situations at a certain distance from the Hills, are higher and drier than those which are nearer to them. Culpettie, standing in a fine elevated country, was comparatively comfortable and healthy, whilst Tewancootshie, due west from the former and close to high land, was found nearly surrounded with wet ground, damp, ruinous and almost depopulated. Towards the southern and eastern extremity of the peninsula, there are many salt marshes, formerly distinct from each other, but four of them now (date of report) joined together, owing to recent inundations. They are separated from the sea by high sand hills, and have no natural communication with it. In common years there is not much water collected

in them, but since the heavy monsoon of 1810, and especially since the rains which fell in February and March, out of all season, they have been filled to a depth of 5, 7 or 10 feet, and the water by remaining long in a state of stagnation has been productive of infinite mischief. In December 1810, the inhabitants of villages near these salt swamps (10 or 12 in number), complained that their houses were rendered uninhabitable, their lands flooded, and that water had risen so high on their Palmyra trees that they were unable to draw the "Toddy." The valley of Courtallum however delightful its climate in June, July, August and September, is far otherwise in February, March, April and May; it partakes of both monsoons, and from its singular topographical position is, in a great measure, deprived of the salutary influence of the southerly winds. At the last mentioned period, it is close, hot and sultry in the greatest degree, and never fails to be most unhealthy. Endemic fever, at such times, is as certainly met with here, as at Gambia or Senegal. On the whole the epidemic fever has raged with the greatest violence in Tinnevelly.

General causes—Believed to be unusual and irregular seasons. Several remarkably dry seasons (themselves healthy), followed by seasons in which an unusual quantity of rain fell, prevailing winds blew with less regularity. Many cattle died, as much from an unnatural state of the atmosphere, as from a want of hands to feed and take care of them.

Progress.—The epidemic was first noticed in certain places close to the Hills, marshy and proverbially unhealthy; and afterwards spread over tracts naturally drier and more healthy. Certain parts of the Madura Collectorate near the sea, as rather further removed from the range of mountains, escaped the disease altogether; with the exception of the inhabitants in the vicinity of a salt marsh. Tinnevelly appears to have been last in suffering from the epidemic. The fever invariably proved most destructive in those villages nearest the Hills, in villages standing low or in the vicinity of marshy lands, and among the poor ill fed and badly lodged population.

The disease which proved so fatal in the southern provinces, does not differ from the common endemic of the country, which, at certain seasons, and in particular situations, may be every year met with. Its having been rendered epidemic on the present occasion, is altogether to be ascribed to the causes already mentioned.

(Signed) W. E. BAKER, Major,
President.

(Signed) T. E. DEMPSTER, Surgeon,
Member.

APPENDIX I.

COPY

To Major W. E. BAKER,
President Canal Committee.

From A. KEIR, *Civil Surgeon,*
Ajmeer.

Ajmeer, 18th January, 1847.

Sir,

I have the honor, in reply to your letter No. 886 of 1846-47, of date the 11th December last, to submit the following observations, as the result of the enquiries I have made regarding the effects of irrigation as practised in this district upon the health of the cultivators.

A.

In the first place, relative to the expression made use of in your communication, "extensive irrigation," I would beg to remark, that it seems applicable rather to denote the condition of the district *as it now is*, with reference to its former unimproved state before coming under Major Dixon's management, than the actual amount of *irrigated* as compared with *unirrigated* land to be found within its limits.

External feature of the country.

Characteristic of this part of the country generally, and of the Ajmeer district in particular, are the numerous ranges of rocky hill which give a bold and rugged aspect to the scenery, but which tend in no less degree to modify the soil and its productions. From these hills come down numerous small streams, the channels of which remain dry during a great part of the year, but speedily fill after a heavy fall of rain. It is by taking advantage of the water thus poured upon the ground, by making embankments, and so laying it under contribution, that some degree of fertility is imparted to a district otherwise of a highly unpromising and unfruitful description. Wonderful indeed and pleasing is the change which has been effected by such means. The waste has been subdued in many places, and instead of a bare, barren-looking surface, producing only a few thorny shrubs, there is now to be seen a smiling sheet of cultivation; and this extending year by year as the skill and industry of the people can be brought to bear on the work of improvement.

Geological character of the hills.

The hills of this district of country belong to the primitive formation. They consist principally of granite rock, (granite and gneiss) quartz-mica and hornblende schist; crystaline limestone is found in the vallies, but the crystals large and the stone of a coarse description. The materials composing the rocky masses are aggregated in every variety of way and proportion, and hence occurs a great diversity in the color, aspect and consistence of the different rocks.

Inclination of the strata.

The general structure of the rocks is schistose, and the strata for the most part have a very high inclination. The dip varies exceedingly. Hereabouts it seems to be most often from west to east; but in other parts the opposite direction prevails. There can be no particular rule laid down in this respect, as regards the lakes or reservoirs for irrigation. These are found on one side of the hill as well as the other, and in the vallies between different ranges. Without minute investigation, the direction of the strata may generally be judged of by the appearance of the hill, the steep abrupt face showing the broken termination of the strata; the opposite more inclined face indicating their direction upwards. In many places, the strata seem perpendicular to the surface, or very nearly so.

Soil.

The soil of the district is composed of the "debris" of these different rocks. It is in a large part silicious; but mica abounds in it and also felspar. The latter ingredient, washed down by the nullahs, exists abundantly in the beds of talaos or tanks, and there gives a clayey consistence to the soil. A "light reddish loam" may perhaps be the appellation most generally applicable to designate the character of the soil. Tried with acids it effervesces tolerably freely. A correct analysis, however, I am not prepared to offer. Calcareous earth is very abundant in some situations, particularly so along the margins of nullahs, where it exists in the form of "kunkur," mixed with other gravelly matter. The proportion of material of vegetable origin is not in general great. Hence the practice of "manuring" is one diligently followed, and the crop in general rises in proportion. Indeed, without "manuring" there is little to be got from a soil so naturally poor. An exception is to be found in this respect in the beds of "talaos," where, from the washings of the stream, there is a rich alluvial deposit, and where, in consequence, excellent crops are raised independent of manure. The ground so favorably situated, however, forms but a small space. The salts which seem most to abound in the soil are those of soda, the muriate and carbonate in particular. In some parts the effervescence on the sur-

Soil, its qualities.

face is very abundant, and this has sometimes [redacted] alkaline and sometimes a strongly saltish taste. Dr. Irvine remarks that the quantity of potash in the soil, comparatively with the quantity of decomposing felspar and mica is small.

But not only is the soil poor as respects the proportion of fertilizing ingredients, it [redacted] likewise, over [redacted] considerable part of the district, deficient as to quantity. The nearness of the rock to the surface may in general be guessed at from its coming into view every here and there. In some places there appear round or tabular masses of rock; in others sharp spinous looking ridges. These latter [redacted] generally of quartz, and indicate the direction of "dykes or veins;" the material from [redacted] hardness having withstood the action which has disintegrated and decomposed the softer rocky masses around.

Country adapted for tanks.

Happily, [redacted] country of this description is well adapted to illustrate what may be done for its improvement by artificial means. The materials are on the spot, and by means of embankment way, even the smallest stream c[redacted] be made to produce its full fertilizing influence upon the soil. To discern the places where embankments may be most fittingly raised requires considerable skill. But [redacted] eye accustomed to such observations will detect the ground where the water may be most easily retained, and where the work can be most advantageously undertaken.

Embankments, their uses.

The object of the embanking process [redacted] not merely to have [redacted] body of water that may be run off for the purposes of irrigation. This, though a legitimate end in many situations, is [redacted] always attainable. [redacted] tank, although it holds water only for a certain period of the year, may still serve a useful purpose by its effects in diffusing moisture throughout the neighbouring soil, and which may thus be rendered [redacted] for cultivation. Some of the richest looking cultivation in the district is to be seen immediately along the margins of the tanks, and, progressively, in its bed [redacted] the waters recede. Another grand object, and the primary one in many cases, in the formation of these tanks [redacted] the replenishment of the wells. Very many of the wells in this district would completely fail in bad seasons, [redacted] yield a most insufficient supply, except for the influence they derive from the neighbourhood of tanks: and here may be [redacted] the admirable beauty and utility of such works, and the [redacted]timable benefit they confer in a district of country where the fall of rain is frequently scanty and [redacted] all times precarious. The water, whatever the season supplies, is kept as in a stone house. It may sink

into the earth; but [redacted] be again drawn forth and poured upon the surface, which thus becomes fertilized [redacted] the time of need.

Wells.

The wells, [redacted] to quantity of water and its distance from the surface, will of [redacted] vary with the state of the tank, at least all those so situated as to be affected by tanks. After a [redacted] of plentiful [redacted] like the past, the water in most of the wells [redacted] abundant and moderately near the surface. From 30 to 40 or 45 feet* may be about the average depth at which [redacted] is obtained, but in this there is considerable variety according to situation and other circumstances. When the rains have been scanty, the supply in the wells is also apt to be [redacted]anty, and may fail during the hot weather. With the ground so [redacted]aturated as it [redacted] there need be no apprehension [redacted] this point. Even a [redacted]ason of "drought" ensuing after one like the past would be but partially felt.

Water of the wells and tanks, the difference.

There is a considerable difference in the chemical proportion of the water [redacted] tak[redacted] from wells or from tanks. The tank water is generally much less impregnated with salts and therefore preferable for domestic purposes and [redacted]st agricultural ones; [redacted] much so is this the case that in many parts the villages may be seen to use the muddied "tank water" [redacted] preference to that from the wells. Where the soil contains a large amount of salt, the well water becomes *entirely* unfit for irrigation. This [redacted] the case [redacted] some parts of the Ramsur district, where the salt effloresces abundantly [redacted] the surface. The evil is corrected in some degree by the [redacted] of tank water, and but for this the extensive khêts to be [redacted] in that neighbourhood could have [redacted] existence. Some crops, however, as the barley, suffer less from this saline impregnation. At the station of Nusseerabad, from the want of tank water, little or nothing can be done [redacted] the way of cultivation. Gardens there are next to useless, and the best efforts lead but to disappointment. At Ajmeer, and this neighbourhood generally, the case is different. The well water is good and answers for irrigation.

Re-agents, effects of, with the water.

Water entirely free from saline impregnation is not to be found either [redacted] the wells or the tanks. From the water of all the wells I [redacted] examined the nitrate of silver throws down a copius precipitate. The "Ana Sagur" water, which [redacted] that of the lake, gives a precipitate

* I have not noticed the depth of water in the [redacted]. I did [redacted] observe this was required till after visiting the villages. Here is 30 feet water at depth of 30 feet, which may be near the average of permanent as distinguished from temporary wells this year.

but very much fainter. In other parts of the district, I have observed the same difference in relation to tank and well water. The oxalate of ammonia gives [redacted] distinct precipitate with the "well water" of Ajmeer but there is none with that of the lake. Solution of pure potass causes a faintish precipitate with the well, but not with the lake water. The nitrate of barytes causes a precipitate with the well, but not with the tank water.

Irrigation, its effects as to the health of cultivators.

As to the effect of the irrigation practised in this district upon the health of the cultivators, information will be best gathered by a reference to the result of my enquiries on that point contained under the head marked B. The investigation was carried [redacted] by myself on the spot, and in the manner directed. Taking the results obtained as affording a criterion by which to judge of the healthiness of the cultivators throughout this district, it certainly leads to the conclusion that irrigation, as here practised, is not in any high degree injurious. The sufferers from spleen are chiefly children. As regards European children, particularly young children, I may remark that the climate of this part of India, [redacted] far [redacted] my experience goes, is not the most favourable. To my questions on the subject of fever, I found it difficult, I may say impossible, often to obtain precise answers. Whether from wilfulness [redacted] forgetfulness, the latter [redacted] believe most generally, there seemed very often [redacted] distinct recollection [redacted] the part of individuals as to whether they had suffered from attacks of fever in previous years or not. On this subject [redacted] good many mis-statements may have been made. The probability is, that when there was [redacted] indistinct recollection as to the occurrence of fever, [redacted] could not, in such cases, have been of a serious [redacted] debilitating kind.

Cultivators their healthy looks.

To form [redacted] judgment as to the health of the inhabitants from their looks and appearance there was the best evidence every where that they were far from an unhealthy race. Indeed, in few of the villages visited could I make out any considerable amount of disease. Among the most common complaints were chronic skin diseases, rheumatism, old and indolent ulcers. A good many *prematurely* old looking persons were to be found, but there is more reason to believe this a consequence of hard work and indifferent food than any effect on their constitutions produced by the climate or soil.

Questions [redacted] to effect of [redacted]tion.

I made enquiries on many occasions, as to whether, with the [redacted] of irrigation, there had been observed any increased amount of sickness. The reply was uniformly in the "negative." So much more, amongst

them, does consideration attach to "plenty" than to health, that the enquiry seemed to be looked upon as a highly absurd one.

The circumstances under which the irrigation is practised and which tend to render it so little hurtful, I conceive to be chiefly the following:

General nature of the climate.

The climate is essentially a dry one, and at the same time salubrious. The villages [redacted] respect to the irrigated land [redacted] almost invariably high in point of situation.

The villages how situated.

For the most part they rest on the slope of a hill, either [redacted] its base or on the steep itself; [redacted] they extend along some rocky ridge. The village of Ramsir, for instance, situated [redacted] it is with a lake on [redacted] hand (and this apt to dry up in some seasons), and [redacted] freely irrigated country on the other, might certainly, from its position, be looked upon as a very *focus* in respect to malaria, yet still, as far as enquiry enabled me to find out, no great unhealthiness appears to prevail. What, in the main, conduces to this favourable, and, so far as appearances go, unexpected state of things, is, I doubt not, the situation of the village, high and dry and upon a rocky ridge. The elevation of the ridge is inconsiderable, but still the houses built upon it may be considered well placed, and [redacted] [redacted] degree removed from the immediate influence of the soil.

Nature of crops irrigated.

The most sickly time of the year is the month of October; and during this month and early in November the days are hot and the atmosphere contains much moisture. Besides this, I believe, that the newly upturned and newly irrigated soil is the most apt to give forth noxious exhalations. The *after irrigation*, provided the fields be kept free of weeds [redacted] they are here, has little if any injurious effect. The fields regularly irrigated are those of the wheat and barley, and the work goes on with little intermission until February. Irrigation is practised for other crops, at different seasons, but to a trifling extent only.

The soil as affected by irrigation.

The circumstance chiefly operative as regards the health of the people employed in irrigation in this district, I conceive to be the "absorbent nature of the soil." The underlying rocks, too, have a highly absorbent character, and hence water poured upon the surface sinks into the earth speedily. It is owing to this property of the soil that the clothing of herbage is every where so scanty. Soon after the first early rain the grass springs up, and the dry, burnt up waste becomes overspread with *green*. When the rain has ceased, [redacted] very soon after, [redacted] change in the appearance of the scene takes place. The surface becomes

ing dry, the more delicate grasses wither, and nothing has [illegible] thriving aspect but the wild shrubs and bushes such as the "ah," the kunserah, the "kenail," &c., which delight [illegible] a barren soil. Trees, when they have once struck their roots deep into the earth, and can draw from [illegible] moisture for their own support, thrive well, but, until they have arrived at this stage of growth, require much care and tending. Hence so few are to be [illegible] and those only in the vicinity of villages.

It is easy to understand why a soil of this kind should be less injurious under the influence of irrigation than one of a different description, where the vegetation becomes more luxuriant, and where, at certain times, it is liable to decay and decomposition. Another favourable circumstance as regards this district is the little disposition of water to stagnate. The ground being inclined more or less in all parts, water runs freely and, conducted into a tank, is in the condition least of all likely to have any prejudicial effect. It is only in the immediate vicinity of Ajmere itself (at the Daulut Baugh, and in front of the magazine), that I have observed any ground covered by water in a stagnant state, and in a state likely to give forth unwholesome exhalations. From the overflowing of the Ana Sagur lake this was partly unavoidable, during the rains at least, but the evil has been allowed to exist long after the remedy, the simple one of draining, might have been applied. That this state of things has produced the great amount of fever that has prevailed in the town the last season, I [illegible] not prepared to say: but it may have had some effect. Other apparent causes exist; and the season moreover has been generally an unhealthy one, although not so, in [illegible] great degree seemingly in the smaller villages of the district.

Inclination [illegible] surface.

Stagnant water.

One point on which information is desired is as to the amount of ground [illegible] state between "dryness and moisture." Of natural swamps or marshes there are none, so far [illegible] I know, in the district. A few swampy spots there may be after heavy rains, but not such as to give any cause for apprehension. The condition of the Ramsir lake I have not observed at all seasons: [illegible] portion of its bed may possibly remain in the state of a swamp during the hot weather, but how much [illegible] in what *precise* condition, I am not able to say. The only *permanently* swampy ground I have observed has [illegible] immediately in the vicinity of tanks and produced either by leakage through the bund, [illegible] by water finding its way by percolation underneath. The ground in this direction, so long [illegible] there [illegible] water in the tank, remains generally *moist*, and this term expresses its condition in most cases better than swamp.

[illegible] marshes.

The drying up of the tanks begins in the opposite direction, or towards the source of supply. When there is much clay in the ground, the surface becomes hard, and *cakes* as the water gradually recedes. When there [redacted] [redacted] due proportion of vegetable mould the soil here is of the best description and affords the richest cultivation.

Drying up [redacted] tanks.

It is when lakes are in [redacted] process of drying that they are most likely to be injurious by giving out malaria. When there [redacted] plenty of water in the Ana Sagur lake [redacted] place [redacted] more desirable as a residence than the bund; but it is not so in particular [redacted] when [redacted] large portion of the bed of the lake has dried up. Most of the other lakes in the Ajmere district are small in comparison, and injurious consequences from this source need not be apprehended.

(Signed) A. KIER, M. D.,
Civil Surgeon.

(True Copy.)

(Signed) W. E. BAKER, MAJOR,
President Canal Committee.

ABSTRACT of Medical Examinations referred to in the foregoing Report.

Villages.	Children of all Classes.		Adults.														Per centage of enlarged spleens.	Depth of water below surface of ground.	Detail of sizes of enlarged spleens.						Per centage of adults having suffered from fever in		
			Brahmins, Fakeers, &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*		*Articans, &c., &c.*		*Menials.*		*Totals.*												
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E		Feet.	VL	L	M	O	S	Total.	1844	1845	1846
Tabeejee, ...	17	3	4	1	5	1	0	0	5	0	1	0	2	1	17	3	15	30	0	0	0	0	6	6	5	20	30
Ramsir, ...	17	3	0	1	2	1	6	2	6	0	1	0	1	0	16	4	17½	5	0	0	0	1	6	7	0	45	35
Dubreila, ...	19	1	1	0	14	0	0	0	2	0	2	0	0	1	19	1	5	25	0	0	0	1	1	2	20	10	25
Neepoolie, ...	20	0	0	0	18	0	0	0	2	0	0	0	0	0	20	0	0	12	0	0	0	0	0	0	5	5	5
Saproonda, ...	18	2	0	0	9	2	0	0	1	1	2	0	5	0	17	3	12½	25	0	0	0	1	4	5	5	5	20
Teharie, ...	14	6	2	1	6	1	0	0	5	3	0	1	1	0	14	6	30	5	0	0	0	1	11	12	30	25	5
Jalowrie, ...	17	3	0	0	3	1	10	4	0	0	0	0	1	1	14	6	22½	0	0	0	1	3	5	9	20	75	90
Nareillee, ...	12	8	0	0	16	0	0	0	0	0	0	0	4	0	20	0	20	15	0	0	0	3	5	8	0	15	25
Googra, ...	18	2	0	0	18	2	0	0	0	0	0	0	0	0	18	2	10	12	0	0	0	1	3	4	0	5	15
Akburrie, ...	13	7	0	0	11	2	0	0	1	0	0	0	4	2	16	4	27½	25	0	0	3	2	6	11	0	35	45
Chacheawas, ..	18	2	0	0	12	1	0	0	1	0	0	0	4	2	17	3	12½	28	0	0	0	0	5	5	5	10	20
Mohurwatee, ..	17	3	0	0	10	1	1	0	5	[illegible]	1	0	0	1	17	3	15	0	0	0	0	1	5	6	5	10	10
Boorhee Pokhur,	16	4	0	0	16	2	0	0	0	[illegible]	1	0	1	0	18	2	15	17	0	0	1	3	2	6	0	15	15
Sirbadana, ...	17	3	2	0	9	3	0	0	2	1	0	0	1	2	14	6	22½	20	0	0	0	0	9	9	5	20	35
	233	47	9	[illegible]	149	17	17	6	30	6	8	1	21	10	237	43	16	18	0	0	0	[illegible]	[illegible]		7½	21	27

[True Abstract] (Signed) W. E. BAKER, Major

and President.

APPENDIX K.

COPY.

From N. COLLYER, Esquire,

Assistant Surgeon Mhairwara Local Battalion.

To Major W. E. BAKER,

President Canal Committee.

Dated, Beawr, 4th February, 1847.

Sir,

I have the honor [redacted] forward for your information the accompanying statement of [redacted] [redacted] of 12 villages conducted by me in accordance with the prescribed form contained in your letter, dated 11th December, 1846; and I beg to state that for the purpose [redacted] investigation I have selected those villages which have the largest tanks and the most extensive irrigation. I am sorry to state that I have not succeeded [redacted] procuring the full complement of children, from their parents having taken them away into the jungle at hearing of my presence, being influenced, I suppose, by fear [redacted] prejudice through ignorance [redacted] the cause for which I required their presence. I trust however that the number of children contained in my report will be found sufficient to indicate the general healthiness of the district and its freedom from ague and spleen.

The general character of the cultivated soil in the immediate vicinity of the hills is of a dark, rich, loamy description, and very productive. It consists of disintegrated mica, schist, and felspar, combined with decomposed vegetable matter and salts of alumina, silica, and potash, with oxide of iron. In other parts [redacted] is of a lighter kind, and abounds with aluminous [redacted]l cretaceous marls. It [redacted] of a highly absorbent nature, the surface of the land quickly becoming dry after the heaviest falls of [redacted] The surface of the irrigated parts inclines naturally from the bed of the tulao.

The rain crops consist of Bajra, Til and Moong with Moth, and are [redacted] without [redacted] [redacted] June, and likewise Mukka, Tobacco and Cotton, which [redacted] manured.

The rubbee cultivation commences at the end of October, and consists of Wheat, Barley, Gram, Sursoo and Opium; and such as are irrigated, if they escape the severe frosts and hail storms, yield a plentiful crop. Irrigation commences in November, and is continued until the end of February or beginning of March.

On the secession of the water the land is ploughed up as soon as it can be worked, and sown with the rubbee crop until the 15th of December. Such portion of the bed of the tank as becomes available for cultivation is sown during the months of February, March and April with Mukka. Thus the inconveniences likely to arise from the gradual drying up of the soil is obviated by its being immediately sown with corn. In view to increase the subsistence of the people the water-nut is freely cultivated on the surface of various of the tulaos, and without any apparent detriment to health. Moist swampy ground abounding with a variety of coarse grasses, and covered with a saline efflorescence (impure sub-carbonate of soda) prevails very generally on the rear of the embankments of all the tulaos.

The diet of the inhabitants consists chiefly of Barley and Mukka with Dal of Moth, Moong, Lobya and Oorud; they are clothed in coarse cotton cloths, and appear very cheerful and contented.

It is a characteristic of the Mhairs that they always locate their villages on heights: hence in a measure may be attributed their general good health.

From about the 15th January to the end of September the prevailing wind is from the south-west. During this period it generally blows strong and steady. During the remaining portion of the year, should any wind blow, it is from the east.

The hills in Mhairwara are all of the primitive formation, and embrace all the varieties of rocks usual under such circumstances: they are principally formed of granite, having separate beds of mica quartz, felspar with hornblende and veins of granular limestone; gneiss is in great abundance, and is used for slabbing the roofs of houses.

The depth of the soil varies greatly in different situations. It is formed of the debris of the hills, mixed up with decomposed vegetation. As a consequence, it is deeper in the vallies than on the slopes of the hills; the greatest depth may be taken at 10 feet, while in other places it is restricted to a slight covering of only a few inches.

In conclusion, I would beg leave to remark that from the observations I have made and from information I have gleaned from other sources, the impression on my mind is that hitherto [redacted] deleterious effects have arisen affecting the health of the inhabitants of Mhairwara either from the large bodies of water which have been collected by the tanks, [redacted] from the [redacted] of that water while being employed largely for the purposes of irrigation.

I have the honor to be, &c.,

(Signed) N. COLLYER, *Assistant Surgeon,*
Mhairwara Local Battalion,
In Medical charge.

Mhairwara,
Beawr, the 4th February, 1847.

(True copy)

(Signed) W. E. BAKER, MAJOR,
President Canal Committee.

ABSTRACT of Medical Examinations alluded to in the foregoing Report.

Villages.	Children of all Classes. N	E	Adults. Brahmins, Fakeers, &c. N	E	Hindoo Cultivators. N	E	Mussulman Cultivators. N	E	Bunnias. N	E	Artizans, &c., &c. N	E	Menials. N	E	Totals. N	E	Per centage of adults having suffered from fever in 1844	1845	1846	Per centage of enlarged spleens.	Depth of water below the surface of ground. Feet.	Detail of sizes of enlarged spleens. VL	L	M	O	S	Total.
Dilwara, ...	20	0	1	0	8	0	0	0	2	0	4	1	3	1	18	2	0	5	40	5	2	0	0	0	1	1	2
Bulhar, ...	20	0	0	0	13	2	1	0	1	0	2	0	1	0	18	2	0	5	15	5	6	0	0	0	1	1	2
Purvrish, ...	10	0	0	0	10	0	0	0	0	0	2	0	7	1	19	1	0	0	10	3½	0	0	0	0	1	0	1
Beawr, ...	20	0	1	0	5	0	0	0	6	1	7	0	0	0	19	1	0	0	15	2½	18	0	0	0	1	0	1
Kullinjur, ...	20	0	0	0	16	0	0	0	1	0	2	0	1	0	20	0	10	0	0	0	6	0	0	0	0	0	0
Gohanna, ..	0	0	0	0	18	0	0	0	0	0	1	0	1	0	20	0	0	0	0	0	7½	0	0	0	0	0	0
Nurbudea Khera, ...	17	0	0	1	12	0	0	0	0	0	1	0	6	0	19	1	0	15	0	2⅔	6	0	0	0	1	0	1
Dewanta, ...	8	0	0	0	6	0	0	0	0	0	1	0	8	2	15	2	0	0	0	8	6	0	0	0	2	0	2
Jowaja, ...	16	1	0	0	15	0	0	0	3	0	0	0	2	0	20	0	0	0	0	2⅔	4½	0	0	0	0	1	1
Loosanee, .. .	15	1	0	0	9	1	0	0	1	0	4	0	5	0	19	1	2¾	0	0	5½	4½	0	0	0	1	1	2
Kabree, ...	15	1	1	0	13	1	0	0	0	0	4	0	1	0	19	1	2⅔	2⅔	0	5¼	4½	0	0	1	1	0	2
Kallee Konkur, ...	11	0	1	0	6	0	0	0	2	0	1	0	9	1	19	1	0	9⅔	0	3¼	9	0	0	0	1	0	1
	172	3	4	1	131	4	1	0	16	1	29	1	44	5	225	12	1¾	3	6	3¼	6				6		

True Abstract.
(Signed) W. E. BAKER, Major,
President.

DR. *Expenditure on the Canals West of the Jumna in Account*

	Original works.			*Establishment.*			*Current repairs.*			*Total.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
As per Captain Blane's bills, from commencement up to 18th May, 1821, ...	142164	10	9½	52264	9	11	5319	13	7½	199749	2	4
As per Captain Colvin and Tickell's bills, from 19th May, 1821 to 30th April, 1822, ...	0	0	0	19095	9	4	6586	11	6	25682	4	10
As per ditto ditto bills of 1822-23,	0	0	0	27612	15	6	9303	2	3	36916	1	[illegible]
As per ditto ditto bills of 1823-24,	0	0	0	43815	5	7¼	6743	10	6	50559	0	1¼
As per ditto ditto bills of 1824-25,	0	0	0	53381	2	5¾	4181	12	5	57562	14	10¾
As per ditto ditto bills of 1825-26,	0	0	0	59029	[illegible]	2¾	4580	4	5	63609	13	7½
As per ditto ditto bills of 1826-27,	4141	10	0	64484	13	2	6830	12	5	75457	3	7
As per Captain Colvin's bills of 1827-28, ...	18145	9	10	73141	7	7	7288	13	8½	98575	15	1½
As per ditto ditto bills of 1828-29,	0	[illegible]	0	74216	1	1	9661	9	1	83877	10	2
As per ditto ditto bills of 1829-30,	4938	14	0	74851	15	7	10435	9	3	90226	6	10
As per ditto ditto bills of 1830-31,	0	0	0	77121	1	1	16252	14	2	93373	15	[illegible]
As per ditto ditto bills of 1831-32,	0	0	0	79718	14	7	20401	5	11	100120	4	6
As per ditto ditto bills of 1832-33,	0	0	0	82242	5	7	22959	8	5	105201	14	0
As per ditto ditto bills of 1833-34,	72010	15	4	81100	0	3	21402	14	8	174513	14	3
As per ditto ditto bills of 1834-35,	90278	8	8	77646	[illegible]	4	36165	5	3	204090	6	3
As per ditto ditto bills of 1835-36,	622222	[illegible]	3½	78949	[illegible]	0	25657	8	6½	726829	6	10
As per Lieut. Baker's bills of 1836-37, ...	3383	7	6	65492	5	5	21892	14	10½	90768	11	11½
As per ditto ditto bills of 1837-38,	31743	2	1	58727	7	2	34804	7	4	125275	0	7
As per ditto ditto bills of 1838-39,	46044	0	11	57201	10	4	21073	11	5	124319	6	8
As per ditto ditto bills of 1839-40,	5562	14	0	54855	13	10	27758	0	8	88869	12	6
As per Captain Baker's bills of 1840-41, ...	31181	1	7	57066	6	5	25785	11	3	114033	5	3
As per ditto ditto bills of 1841-42,	12120	15	0	55425	14	8	28197	9	7	95744	8	0
As per ditto ditto bills of 1842-43,	25115	14	0	53104	15	11	43915	4	5	122136	2	4
As per ditto ditto bills of 1843-44,	8408	11	9	59721	3	0	31712	15	9	99842	14	6
Total cost up to end of 1843-44,	1118156	1	8	1480267	11	0½	445912	7	5	3047336	4	1½
As per ditto, 1844-45,	2639	6	3	67069	11	3	89689	14	5	159399	0	0
As per ditto, 1845-46,	17184	0	5	68238	1	4	62559	2	4	147981	3	11
As per ditto, 1846-47,	56769	6	4	71559	4	0	53976	10	6	182305	4	11
Total cost up to end of 1846-47,	1194748	14	8	1687344	11	7½	656138	2	8	3537321	12	11½

5

Current with direct Canal Revenue derived thereupon. Cr.

	Water rent on land irrigation.			*Rent on the water mills.*			*Rent on cattle watered.*			*Rent for rafting timbers.*			*Sale of the Canal produce and all sundry rents.*			*Fines for breach of Canal regulations.*			*Total direct Revenue.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
Previous to 1820,	876	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	876	4	0
1820-21,	14646	2	1	0	0	0	0	0	0	14	4	0	635	11	0	504	[illegible]	5	15800	9	6
1821-22,	24618	8	11	0	0	0	0	0	0	84	4	0	1,180	9	4	911	[illegible]	2	26794	14	5
1822-23,	21,458	5	0	3026	13	6	0	0	0	0	0	0	741	7	11	1,039	2	10	26265	13	3
1823-24,	36015	6	1	6868	10	0	0	0	0	[illegible]	0	0	656	0	10	1882	3	8	45422	4	7
1824-25,	26646	9	7	3964	5	4	0	0	0	0	0	0	545	7	7	1082	8	8	32238	15	2
1825-26,	48374	6	9	2991	3	11	0	0	0	0	0	0	370	9	9	2423	4	4	54159	8	9
1826-27,	33975	0	0	3682	13	2	0	0	0	500	4	0	713	13	11	3283	1	6	42155	0	7
1827-28,	34160	14	7	11676	10	9	0	0	0	1013	1	10	1460	13	9	4471	1	9	52782	10	[illegible]
1828-29,	52952	10	7	16267	[illegible]	6	3772	10	8	1187	1	10	1289	8	8	2847	6	2	78316	6	5
1829-30,	53375	0	0	19786	3	0	3568	7	10	1932	10	4	1142	15	4	2801	12	4	82607	0	10
1830-31,	57700	0	5	19464	[illegible]	0	2968	12	2	2132	8	4	1265	4	8	2508	9	6	86039	3	1
1831-32,	51016	4	11	19002	3	7	4210	9	7	2061	15	0	2127	7	0	2463	2	10	80881	10	11
1832-33,	65804	11	3	19238	2	3	3396	2	5	1611	8	7	2651	2	11	3410	4	5	96111	15	10
1833-34,	148783	2	6	13882	4	6	1257	3	11	2950	1	6	3894	6	11	6064	11	3	176831	4	7
1834-35,	114065	8	3	18294	9	9	1669	6	7	3238	9	5	3682	2	10	4308	2	10	145253	17	8
1835-36,	110602	11	3	22837	3	7	2145	15	6	1993	9	0	4957	11	9	2603	13	4	145141	0	5
1836-37,	153176	15	1	26894	10	5	2197	1	7	3365	0	0	2245	6	0	2930	5	[illegible]	190809	6	4
1837-38,	272377	13	5	5782	6	9	760	3	6	6048	9	5	5221	8	8	9480	8	9	299670	12	6
1838-39,	189614	15	3	9732	7	10	1838	15	3	8228	11	4	6171	4	2	5783	12	0	221400	1	10
1839-40,	224382	15	3	14566	8	3	2286	13	2	6579	5	1	4822	14	10	6188	2	2	258826	10	9
1840-41,	225817	15	3	9524	6	6	1955	13	2	9730	4	3	5481	6	0	6077	13	0	288587	4	2
1841-42,	263068	13	0	8203	14	3	1554	1	8	11505	15	3	5607	3	7	4632	9	6	294572	9	3
1842-43,	279300	10	11	9882	11	9	1172	5	2	7934	14	9	6756	12	3	6218	1	0	311265	7	10
1843-44,	260555	8	9	12598	13	0	1680	4	9	5570	12	6	4827	5	2	5760	14	3	296993	10	5
	2,793,397	[illegible]	1	278,167	6	7	36,434	14	11	76837	6	5	68449	2	10	89672	7	11	3343804	11	9
1844-45,	231,022	[illegible]	9	8,220	6	[illegible]	2979	7	2	6598	10	8	5,149	11	1	6,341	3	2	260311	15	1
1845-46,	260693	13	2	13,250	7	11	2293	3	2	7830	0	4	7,056	0	1	7,753	4	6	295876	13	3
1846-47,	262,529	13	8	14,709	15	5	1,687	0	0	6799	9	1	10,167	10	4	6,991	2	9	302,685	3	3
	3547643	8	8	43394	9	4	43394			95911	10	6	90,822	8	4	1,10,756	[illegible]	[illegible]	42,05,878	11	4

DR. *Expenditure on the Dooab Canal in Account Current*

	Original work.			*Establishment.*			*Current repairs.*			*Total.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
As per Captain Smith's Bill from commencement to 31st December, 1830, ...	311239	12	4½	122831	0	6	0	0	0	434070	12	10½
As per Captain Cautley's audited bills from 1st January to 30th April, 1830, ...	0	0	0	3924	12	0	0	0	0	3924	12	0
Ditto ditto of 1830-31, ...	0	0	0	29658	10	2¾	3958	1	9 1/12	33616	12	[illegible]
Ditto ditto of 1831-32, ...	12022	4	9¼	47905	11	2½	4476	0	9¼	64404	0	[illegible]
Ditto ditto of 1832-33, ...	11153	7	6	27870	5	9	10929	13	0½	49953	10	[illegible]
Ditto ditto of 1833-34, ...	19370	13	10	31767	14	5	20517	13	0½	71656	9	[illegible]
Ditto ditto of 1834-35, ...	40256	10	6	30999	10	7	24295	8	3½	95551	13	[illegible]
Ditto ditto of 1835-36, ...	36583	7	0	29870	1	11	24234	8	0	90688	0	11
Ditto ditto of 1836-37, ...	26599	7	10	41044	4	8	30274	0	5½	97917	13	11½
Ditto ditto of 1837-38, ...	8744	8	10	32727	8	0	24909	11	5	66381	12	[illegible]
Ditto ditto of 1838-39, ...	33208	1	10	33820	2	1	33453	9	9	100481	13	8
Ditto ditto of 1839-40, ...	1138	11	6	33462	7	10	40518	8	4	75119	14	[illegible]
Total cost up to end of 1839-40, ...	500317	8	10½	465882	9	2¼	217567	10	11⅙	1183767	11	[illegible]
Ditto ditto of 1840-41, ...	25168	5	8	34479	2	0	34642	5	1	94289	12	9
Ditto ditto of 1841-42, ...	99396	10	3	34794	10	1	30644	11	9	164836	0	1
Ditto ditto of 1842-43, ...	10609	1	9	33971	15	9	37740	2	7	82321	[illegible]	1
Ditto ditto of 1843-44, ...	119605	1	3	31230	7	1	35876	7	11	186712	0	3
	755096	14	9½	600358	10	1¼	356471	6	3⅙	1711926	15	[illegible]
Ditto ditto of 1844-45, ...	30385	2	5	30738	11	0	30931	12	1	92055	9	6
Ditto ditto of 1845-46, ...	11427	0	0	33900	10	8	34054	2	6	79381	[illegible]	2
Ditto ditto of 1846-47, ...	17653	2	1	34558	9	0	38800	7	9	91072	2	10
Total cost up to end of 846-47, ...	814592	3	3½	699586	8	9¼	460257	12	7⅙	1974436	8	[illegible]

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with direct Canal Revenue derived thereupon. Cr.

	Water rent on land irrigated.			*Rent on the water mills.*			*Rent on cattle watered.*			*Rent for rafting timbers.*			*Sale of the Canal produce and all sundry Rents.*			*Fines for breach of Canal regulations.*			*Total direct Revenue.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
1830-31,	6083	5	9	884	12	5¾	2	4	4½	0	0	0	592	15	3	730	0	3½	8293	6	1¾
1831-32,	7551	2	2	2476	10	2	107	3	2	9	7	9½	606	6	2	1209	0	8	11959	14	1½
1832-33,	22107	0	0	4902	15	10¾	83	14	5	11	12	3½	665	7	7½	1075	13	0	28846	15	2¾
1833-34,	46964	15	2	4435	13	4½	52	5	6½	7	5	2½	773	11	8	1270	1	5	53504	5	4¼
1834-35,	37918	5	6	3335	6	5	100	12	5	0	0	0	815	15	5¼	1250	12	1	43421	3	10¼
1835-36,	37081	5	3	4728	0	7¼	63	13	0	0	0	0	1034	9	4	1325	1	4	44232	13	6¼
1836-37,	44308	6	0	5154	11	2½	61	10	0	88	12	4½	1168	5	2	735	10	7	5151	7	7¼ 5817-7-4
1837-38,	91315	9	1	5001	6	9	189	13	0	262	3	0	1222	5	2	2847	14	6	100839	3	[illegible]
1838-39,	73014	15	10	4358	4	6	104	0	0	426	8	1	1073	9	1	2967	13	0	81945	2	6
1839-40,	78543	9	11	4288	4	2	65	14	0	566	12	7	1252	8	[illegible]	3812	6	9	88559	7	5
	444888	10	8	39566	5	6¾	831	9	11	1372	13	4	9285	12	10¼	17224	10	7½	513119	15	0
1840-41,	89135	14	6	3297	9	2	97	14	0	0	0	[illegible]	2470	[illegible]	5	4322	8	11	99323	15	0
1841-42,	75885	8	5	5733	12	6	153	14	[illegible]	963	2	11	1645	3	5	3785	6	1	91164	15	4
1842-43,	107064	0	8	6194	0	9	32	10	0	522	2	8	1940	7	[illegible]	3683	0	3	119436	5	10
1843-44,	86147	1	3	8178	13	0	137	4	0	351	5	11	1413	12	9	4535	4	4	100763	9	3
	806121	3	6	62970	8	1¾	1253	3	11	3209	8	10	16705	4	11¾	33548	14	2½	923808	12	5
1844-45,	84786	2	0	6045	4	3	217	15	0	280	14	[illegible]	1704	1	11	5736	4	7	98770	10	2
1845-46,	96534	4	4	8121	15	8	103	[illegible]	[illegible]	414	10	[illegible]	1725	11	1	3086	6	11	109986	8	9
1846-47,	107725	1	8	7838	0	6	305	0	10	609	2	1	1842	0	11	3433	6	7	121752	2	7
	1095166	11	6	84975	12	6¾	1879	11	9	4514	4	1	21977	2	10¾	45805	0	3½	1254318	11	11

General Summary of Expenditure on the Ganges Canal to 31st August, 1845.

Establishment—From commencement to 31st August, 1845, and general Superintendence from 1st September, 1843 to 31st August, 1845, ...	95285	14	1
Sundries—Including extra Draughtsmen in Superintendent's office,	4215	8	4
Excavation—Comprising about 10 miles of Canal channel completed, including the 1st annual repairs and grassing of slopes about 5 miles of Canal channel in progress and heavy excavation of shingle at site of the Myapoor Dam and Regulator also in progress, ...	377639	1	1
Masonry works—Comprising the foundations of the Myapoor Dam and regulating Bridge, rivetments of the high gravel banks adjoining thereto up to the height of 8 feet. The foundations of a bathing Ghat and the Bythuk wall at Myapoor. The road and inlet Bridges of the Bochna nulla, workshops at Myapoor, model room and offices and range of Smith's and Carpenter's shops; Store rooms, &c., at Roorkhee, 1st class chokies at Myapoor, Muhmoodpoor and Belra and 2nd class chokies at Munglour, Dimat and Toghulpoor, (not including cost of bricks used in them),......	18585	11	6
Brick making—Comprising the preparation of Government and contract kilns, as near the site of the principal masonry works as fuel could be obtained. Many of the kilns have totally or partially failed, and those of last year having not yet been unstacked, the precise number of serviceable bricks is not known, but may be roughly estimated at two hundred lacs,	119318	0	1
Workshops and purchase of store materials, such as lime, iron, stone, &c., ...	36460	0	9
Bullocks—Cost of maintaining to be charged hereafter to the works on which they were employed, ...	2418	3	2
Compensation—For land and property, and remission of land revenue, ...	5730	4	8
Grand total expenditure up to 31st August, 1845, Co.'s Rupees,	659652	11	8

Present Monthly Establishment of the Ganges Canal, (including half the expense of the Director's office, the other half being fairly chargeable to the other Canals under his superintendence), ... Co.'s Rupees, 3800 0 0

(Signed) W. E. BAKER, Captain,
Director of the Works, Ganges Canal.

Statement of the gross value of crops grown [redacted] land irrigated from the Dehlie Canals in 1837-38, the greater part of which land would have been totally unproductive without the use of Canal water.

KHUREEF CROPS.

		Co.'s Rs.	A.	P.
20490	Beegas of Sugar-cane and Indigo [redacted] 50 rupees per beega,	1024500	0	[redacted]
75242	Beegas of Cotton at 12 maunds of Kupas (or Cotton with seed) per beega and 16 seers of Kupas per rupee,	2257[redacted]	[redacted]	0
74010	Beegas of Rice, Jowar, &c., @ 15 maunds per beega, and 25 seers per rupee or 24 rupees per beega, ...	1776240	0	[redacted]

RUBBEE CROPS.

		Co.'s Rs.	A.	P.
19000	Beegas of Wheat, Barley, Gram, Mustard, &c., &c., at 15 maunds per beega, and 20 seers per rupee or 30 rupees per beega, ...	9570000	0	
	Company's Rupees,......	14627940	[redacted]	[redacted]

In the above statement the produce per beega is stated at the lowest [redacted] age of the statements I have collected from Zemindars of the produce of their fields, and will not be considered more than might be expected from land well cultivated and plentifully irrigated. The valuation is also lower than the market prices have been within my experience during the last six months. Of this [redacted] of 146 lacs of rupees about 1-10th is recovered by Government [redacted] account of land tax and water-rent; the remainder covers the expenses of cultivation and provides maintenance for the population of near 500 villages.

(Signed) W. E. BAKER, Lieut.,
Superintendent Canals.

Dated,

1838.

APPENDIX C

Quarterly System of Accounts and Bills as practised in the Ganges Canal.

The accompanying papers are drawn up so as to represent the entire working of a Quarter's accounts of a Division and consist of the following papers:—

Appendix A—

The Daily Cash Account of the Division. This paper scarcely needs remark, as it is sufficiently explanatory in itself. It is similar to that used in all Offices of Account. It should be kept neatly and carefully and duly posted up [illegible] [illegible] [illegible] [illegible] [illegible] the cash transactions of the Division. Upon it is distinctly shown all [illegible] from Government Treasuries and remittances with disbursements [illegible] [illegible] [illegible] [illegible] and Contract [illegible] Sub Divisions. [illegible] [illegible] [illegible] [illegible] and balance [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] after satisfying himself of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] figures [illegible] [illegible] [illegible] [illegible] the amount [illegible] [illegible] [illegible] [illegible], that [illegible] [illegible] [illegible] hereafter.

Appendix X.

These papers exhibit the forms of Accounts submitted by the Sub [illegible] in charge of Sub Divisions, each month's Accounts being supposed to be that of a separate Sub Division though for convenience sake the whole [illegible] [illegible] to make up a Quarter's [illegible]

for

for one work only, which [illegible] being the largest and most detailed in the [illegible] of [illegible], periodically [illegible] [illegible] the most illustrative of the System. On the receipt of these Sub-divisional papers, the clerk of the Office examines them, [illegible] each a copy, [illegible] that in any instance, [illegible] done [illegible] returns. [illegible] to the Superintendent to whose [illegible], [illegible] of each item in Character, [illegible] particulars, and [illegible] which character, [illegible] the [illegible] distinctly to what Heading in the Office Accounts, [illegible] [illegible]. [illegible] other [illegible] papers, independently of those illustrated, which are [illegible] from the Sub-Divisions, [illegible] Reports, &c. [illegible], Reports, Abstracts of Accounts, [illegible], or [illegible] indispensable to the illustration of the System of Accounts, [illegible] to take [illegible] the receipt of all the monthly papers back again from the [illegible] [illegible]

[illegible] monthly papers as follows:

Appendix B.

There is an Office Account current between the Sub Divisional subordinate and the Superintendent. It differs only from the subordinate's own Account Current in so far that in the latter the subordinate debits himself only with cash received from the Superintendent and credits himself only with the cost of Labor expended on the works as well as with expenditure for the petty purchases of materials &c.; whereas in the former he is debited with the value of all materials delivered into his charge and credited with the value

of

of work executed including the cost of both Labor and Materials. This has been found a very convenient method of procedure inasmuch as it saves the Office much labor and valuable time, and although it entails a very small amount of extra labor (on) each individual Subordinate, that extra labor is amply compensated for in the information it gives the Subordinate of the actual Cost of the work done which he could never possess, did he not thus calculate the cost of all the materials expended upon his works. This system enables the Superintendent also, when going over his subordinates accounts, to detect any extravagant expenditure and to correct it, or to see when work is being economically carried out and to bestow praise on the Subordinate so doing, which he could not have done had he to wait for a month or two until the accounts were completed in the Office. The Subordinates are supplied periodically with lists of the usual rates to be charged for materials; these rates are average ones, being struck quarterly or half yearly as most convenient or most needed. The Subordinates then, when entering the quantities of materials expended carry out their cost also and thus show in their Daily Reports the cost in Labor and Materials of all works executed during the month.

Appendix C.

This is a Division Account Current showing at one view the sum of the transactions of the Sub-Divisions and the Office during the month. It is debited with

with all cash received from Government and is credited with the cost of all work executed and purchases &c. made throughout the Division during the month.

Appendix Y.

Shows an Abstract of the Sub-divisional Daily Accounts, showing the total expenditure during the month in Labor, Material, &c., under each of the Headings of Original Works, Repairs, [illegible] (Office of Materials (the Store)), Sundries, Tools, Current Expenses and any other specific Headings the Superintendent may adopt, and from this paper all these items are debited off to their respective places in the Books, which are in three Columns, viz:

Original Works Account Book — Appendix — E.
Repairs Account Book ——— Do — F.
Miscellaneous Account Book — Do — G.

The [illegible] headings adopted by the Superintendent in dividing off his Accounts to their separate Headings, and the [illegible] used to distinguish them, which are simple enough. They are always represented in [illegible] to distinguish them from the rest of the Columns, and are as follows [illegible], being such as that may be convenient.

A [illegible] | C [illegible] | M [illegible]

[illegible]

R [illegible]

F [illegible]
S [illegible]
T [illegible]
N [illegible]

The Accounts being all properly prepared for entry, the several items of expenditure and Receipts are duly posted to their respective pages of Account under the Headings just described, the first of which

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Appendix E.

is a very simple and useful account Book, and is that from which the Superintendent makes out his Bills. It consists of 2 pages to each Work or Heading, the first of which contains the debits and credits to the Account (the former being posted from the Abstract Book and the latter from the Bill Book). The second page is a very useful appendage and makes the whole a very valuable and complete record; as it shows at once the value of all the items of expenditure, the work done and the value of it, for each individual item; and it enables the Superintendent to take up the Book and make out his Bills without any trouble or reference whatever. It performs moreover the duty of making the account perfectly clear to any body.

Appendices F and G.

are filled in, in the same way, with the exception of the detailed explanation of debits, which may or may not be kept as the nature and extent of the transactions may demand, it being decidedly advisable to maintain the detailed explanation when ever the Accounts are heavy and extensive. The Stone accounts get credit for the materials expended on the works, and the Miscellaneous Accounts get them credit, as the state of the Works and Accounts enables the Superintendent to adjust them. Thus the miscellaneous accounts may all be called fluctuating

accounts

accounts with exception to the Government Con-
pendo Accounts which are adjusted by monthly
Current Bills.

Appendix H.

As a check Book — which it is necessary to keep
to enable the Accountant to determine the cor-
rectness of his accounts — it is kept on the [illegible]
[illegible] Double Entry and prior, its explanation
being a repetition in as short a form as
possible of the former paper — the debits and
credits of every account agreeing exactly
with each other. The Balance sheet of
this check Book shows at a glance the
state of the affairs of the Division and
being closed [illegible] the [illegible] is enab-
led to make up his [illegible] Account Cur-
rent — given in — Appendix D.

This Account Current is however submitted
only Half yearly — It is submitted to the
Accountant Public Works [illegible] by
whom it is checked — and any errors that may
exist are officially notified to the Superintendent
for correction. This Account is debited with
all charges made by the Government against
the Division [illegible] cash or Stores supplied from
the different Government Departments — and
is Credited only with Bills duly audited; the
way in which the Balance unaudited or unac-
counted for is disposed of being explained un-
der the Head of Unexplained Balances.

Roorkee
[illegible] March 18[illegible]

[illegible]
Accountant [illegible] Office
Ganges Canal Works.

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Appendix A.

Day Book —

Cash Account Continued.

[illegible]

Daily Particular Cash Account of the [illegible] Division of the Ganges Canal.

Date	Description	Received	[illegible]
18[illegible] February 1	Camp Muhewur.		
	To Balance of last Account	10,000 " "	
	To Cash received from the Collector of Saharunpoor in lieu of Allignment [illegible] drawn by the Accountant N.W.P. on the Saharunpoor Treasury	75,000 " "	
2	Camp [illegible]		
	Advance to [illegible] Contractor for [illegible] Timber,	" " "	20[illegible]
	Advance to Mr. Finn Executive Officer of Materials	" " "	20[illegible]
15	Camp [illegible]		
	Amount remitted to Overseer	" " "	50[illegible]
	Advanced to Mr. Finn Executive Officer of Materials	" " "	20[illegible]
25	Amount remitted to Overseer	" " "	40[illegible]
	Advance to Mr. Finn Executive Officer of Materials	" " "	20[illegible]
28	Advance to [illegible] Contractor for the [illegible] Timber,	" " "	50[illegible]
	Totals	85,000 " "	7[illegible]
	Balance in hand	" " "	7[illegible]
	Grand Total — Co.'s Rs.	85,000 " "	[illegible]
March 1	Camp Dhunowree		
	To Balance of last account	9000 " "	
9	Cash paid to [illegible] Hospital [illegible] [illegible] from [illegible] Banks digging [illegible] wages for 8 days @ [illegible] per day		" " "
	To Cash received from the Collector of Saharunpoor in lieu of Allignment [illegible] drawn by the Accountant N.W.P. on the Saharunpoor Treasury	75,000 " "	
10	Camp [illegible] Kullewur		
	Amount remitted to Overseer		" " "
	Advanced to Mr. Finn Executive Officer of Materials		" " " 9[illegible]
15	Camp [illegible]		
	Amount remitted to Overseer		" " " 10[illegible]
	[illegible] Contractor Amount of his [illegible] completion of [illegible] Aqueduct		" " "
	Carried forward — Co.'s Rs.	84,000 " "	[illegible]

	Description	Received	Expended
	Brought forward ...	84,000 " "	38,292 4 5
	[illegible]		
	Advance to the Executive Officer of Materials	" " "	20,000 " "
31	Advance to [illegible] Agent [illegible] Amt of Their Bills for purchase of [illegible] miscellaneous [illegible]	" " "	22,000 " "
	Totals	84,000 " "	80,292 4 5
	Balance in hand	" " "	3,707 11 7
		84,000 " "	84,000 " "
1	To Balance of last Account	3,707 11 7	
5	[illegible] To Cash [illegible] from the Collector of [illegible] in [illegible] [illegible] the Accountant [illegible] Treasury	75,000 " "	
10	Amt remitted to [illegible] Superintendent	" " "	1,000 " "
	Advanced to Executive Officer of Materials	" " "	20,000 " "
15	Amt Remitted to 2nd Superintendent	" " "	15,000 " "
16	Do. Do. Do.	" " "	5,000 " "
25	Advanced to Executive Officer of Materials	" " "	20,000 " "
31	Remitted to [illegible] Superintendent to pay Regular Establishment for Current month	" " "	41 " "
	Do. Do. to pay fluctuating do do do	" " "	180 " "
	Amt paid to Treasurer for 209 [illegible] [illegible] of [illegible] employed on Excavation in the 15th and 16th Miles @ yearly contract rate of [illegible] per [illegible]	" " "	419 10 2
	Totals	78,707 11 7	61,640 10 2
	Balance in hand	" " "	17,067 1 5
	Total ... [illegible]	78,707 11 7	78,707 11 7

[illegible] in hand 17,067 1 5 [illegible] thousand [illegible]

C. [illegible] Captain
Superintendent [illegible] Ganges Canal

Appendix X

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Overseer ______'s accounts

for the month of

February 1853

Cash Account current during the month of February

Dr.

Date	Receipts	Amounts
February 1	To Balance in hand	
15	To Cash received from the Superintendent	5,000 " "
25	" Do. Do.	4,000 " "

Total credits

12 6

…tendent of the Northern Division Ganges C…

Roorkee. 1st March 1853 Cr:

Expenditure.	Amount	Total.
By Amount paid for Labour during the month of February 1853: Viz. as per Daily Account:		
„ 1st Embankment	1446 9 8	
„ 2 Do.	1470 12 10	
„ 3 Do.	668 2 „	
„ 4 Do.	417 8 2	
„ 5 Do.	532 6 4	
„ 6 Do.	170 12 3	
„ 7 Do.	40 10 4	
„ 8 Do.	269 „ „	
„ 9 Do.	904 6 4	
„ 10 Plantations	9 „ „	
„ 11 Brick Kilns	10 9 4	
„ 12 Do.	28 15 8	
„ 13 Lime Kilns	5 „ „	
„ 14 Repairs	18 15 4	
„ 15 Do.	„ 8 „	
„ 16 Do.	5 „ „	
By Regular Establishment for February 1853	10 „ „	
„ Fluctuating Do. Do.	144 11 1	
„ Purchase of Country Paper	1 „ „	6884 1 „
Balance in hand		2,415 15 „
Total Co's		9,300 „ „

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E. E.

Rs.

Over Seer

Ganga Canal
appendise.
Sig I vol [illegible]

Daily Account of Expenditure on the [illegible] during the month of February 1853.

No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Excavation. 15th Mile. Wagons drawn by Horses.	Excavation. 16th Mile. Wagons drawn by Horses	Same as No. 2. Wagons propelled by Men.	Spreading No. 1, 2 and 3.	Excavation [illegible] Men.	Spreading No. 5.

Work	Rate and Description	Amount			Totals		
No. 1	Mates @ 6d.	1146	9	8	1146	9	8
	Bildars @ 4d.	800	"	"			
	Tyres @ 5d.	500	"	"			
	Basket [illegible]	50	"	"			
	Grass for [illegible]	300	"	"			
	Oil [illegible] 5d.	19	9	9	369	9	9
					1,816	3	5
No. 2	Mates @ 6d.	74	13	10	1474	13	10
	Bildars @ 4d.	850	"	"			
	Tyres @ 5d.	550	"	"			
	Tallow	10	"	"			
	Basket [illegible]	10	"	"			
	Horse feed	472	13	2	492	13	2
					1,967	11	"
No. 3	Mates @ 6d.	8	2	3	668	2	"
	Bildars @ 4d.	659	15	9			
	Basket [illegible]	50	"	"			
	Grease	1	10	6	51	10	6
					719	12	6
No. 4	Mates @ 6d.	117	6	10			
	Bildars @ 4d.	1000	1	10	1117	8	8
No. 5	Mates @ 6d.	28	6	4			
	Bildars @ 4d.	500	"	"	528	6	4
No. 6	Mates @ 6d.	11	12	5			
	Bildars @ 4d.	179	"	"	190	12	5

Date	No. 1					No. 2					No. 3				No. 4		No. 5		No. 6	
1	25	200	100	100	2	10	31½	110	2	10	2	165	100	[illegible]	20	250¾	7½	125	2	45
2	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
3	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
4	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
5	25	200	100	100	4	15	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
6	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
7	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
8	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	"	125	2	45
9	25	200	100	100	4	10	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
10	25	200	100	100	4	15	31½	110	2	10	2	165	"	"	20	250	7	125	2	45
11	25	200	100	100	4	20	31½	110	2	10	1	165	"	"	20	250	7	125	2	45
12	25	200	100	100	8	20	31½	110	2	10	1	165	"	"	20	250	6	125	2	45
13	24	200	100	100	8	15	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
14	24	200	100	100	8	20	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
15	24	200	100	100	8	15	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
16	24	200	100	100	8	20	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
17	24	200	100	100	8	10	31½	110	1	10	1	165	"	"	20	250	6	125	1	45
18	24	200	100	100	8	10	31½	110	1	10	1	165	50	"	20	250	6	125	2	45
19	24	200	100	100	8	10	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
20	24	200	100	100	8	10	31½	110	1	10	1	165	"	"	20	250	6	125	2	45
21	24	200	100	100	8	10	31½	110	1	10	1	165	"	"	18	250	6	125	2	45
22	24	200	100	100	4	10	[illegible]	110	1	10	1	165	"	"	18	250	6	125	2	45
23	24	200	100	100	4	10	31½	110	1	10	1	165	"	"	18	250	6	125	2	45
24	24	200	100	100	4	10	31½	110	1	10	1	165	"	"	18	250	6	125	2	45
25	24	200	100	100	4	10	31½	110	1	10	1	165	"	"	19	250	6	125	2	45
26	24	200	100	"	4	10	31½	110	1	"	1	165	"	"	19	250	6	125	2	45
27	24	200	100	"	9	10	31½	110	1	"	1	165	"	"	19	250	6	125	2	45
28	24	200	100	"	[illegible]	10	31½	110	1	"	1	165	"	"	19	250	6	125	2	45
	684½	5600	2800	2500	1.0.0	349½	5950	3080	1.0.0	250	38	4620	1250	0.6.10	549	7000¾	179½	3500	55	1253

Total Cost on No. 1 · Total Cost on No. 2 · Total Cost on No. 3 · Total Cost on No. 4 · Total Cost on No. 5 · Total Cost on No. 6

5,00,966 Cubic feet of Earth excavated, filled into Bullock Wagons and propelled along the line by horses an average distance of 8516 feet and emptied in [illegible] of Railway.

3,99,300 Cubic feet of Earth excavated [illegible] as in the before going and an average distance of 11,556 feet and emptied as before.

2,19,112 Cubic feet Earth as before [illegible] an average distance [illegible] 7000 feet.

11,02,378 cubic feet of Earth spread in [illegible]

1,24,525 cubic feet as before, but propelled by Men an average distance being of 5000 feet.

[illegible]

S. K. P. 65

...ed Works of the Northern Division Ganges Canal
Roorkee 1st March 1853.

No. 10 Plantations

30 Seers planted. 35
1000 Bamboo ... 28, 50

Item	Rs. As. P.
Bildars	5 " "
Malees	4 " "
Bamboos	1 " "

Total Cost on No. 10 — 10 " "

No. 11 Brick Kiln at Mahewur

600 cubic ft. of Earth excavated. 11
20000 Bricks placed in kilns. 20 / 60

Item	Rs. As. P.
Bildars	1 9 4
Contractors	9 " "
Coolies	8 12 "
Baskets	" 10 8

Total Cost on No. 11 — 20 " "

No. 12 Brick Kiln at Roorkee

30 thousand Bricks ... 12, 21

Item	Rs. As. P.
Bildars	1 13 8
Moulders	27 2 "
Coolies	20 " "
[illegible]	1 " 4

Total Cost on No. 12 — 50 " "

No. 13 Lime Kiln at Myapoor

One Kiln ... 22, 24
... ready for ... 50

Item	Rs. As. P.
Bildars	1 9 0
[illegible]	2 4 8
Wood	

Total Cost on No. 13 — 10 " "

No. 14 Repairing Bunds

24, 2, 15, 50, 20

Item	Rs. As. P.
Bildars	3 11 4
[illegible]	" 4 "
Coolies	13 " "
Grass	" 2 8
Baskets	" 4 "

Total Cost on No. 14 — 20 " "

No. 15 Tronments of Gates

... feet of ... needed ... for gates. 6

Item	Rs. As. P.
Smiths	" 8 "
Iron	4 8 "

Total Cost on No. 15 — 5 " "

No. 16 Repairing Kulsea Chowki

40 Sq. feet of masonry executed.
50 Sq. feet of plaster.
Whitewashing ...

18, 1, 1000

Item	Rs. As. P.
Masons	4 8 "
Mistries	" 8 "
Bricks	5 " "
Lime	23 8 "
Soorkee	4 12 10

Total Cost on No. 16 — 37 4 10

(Signed)

Executive ...

Pay Bill of Establishment attached to the Northern [Divi]sion of the Ganges Canal during the month of February 1853

Roorkee 4th March 1853

[Descr]iption	Names	Amount	Total	Nature of Establishment
[Mun]shi	Ighram		10 . .	Permanent
	Kulloo	20 . .		
[Mo]addi	Jaffer Ali	15 . .		
	Bridjlal	8 . .		
	Saadut Ali	7 . .		
[Ch]ao lee	Kulloo	5 . .		
	Jehangeer Khan	5 . .		
	Sahib Sing	5 . .		
	Heera Sing	5 . .		
	[illegible]	5 . .		
	Doulut Ram	5 . .		
	Dakee Singh	5 . .		
	Ruttun Singh	5 . .		
	Ragubir	5 . .		
	Khoput	5 . .		
[Bel]dar	Lulla	4 . .		
	Oree	4 . .		
	Lodhee	4 . .		
	Jarao	4 . .		
	Kwajoo	4 . .		
	Domda Khan	4 . .		
	Sultoo	4 . .		
	Gunga Ram	4 . .		
	Ram Lal	4 . .		
	Poorun	4 . .		
	Ramdeen	4 . .		
	Lobeedeen @ 4/- 3 days	. 11 1	144 11 1	Fluctuating
	Total Co.'s Rs.		154 11 1	

[The] above men were all paid in my presence.

(Sd.) ______

Overseer

Appendix X.

Preston ——— Crowns
for the month of
March 1853.

(13

Overseer in Account Current with
Ganges Canal for the month of March

Dr.

Date		Receipts	Amount
March	1	To Balance in hand	[illegible]
	10	To Cash received from the Superintendent	5000
	15	Do. Do. Do.	10,000
		Total Rs.	[illegible]

Superintendent of the Northern Division of the

Roorkee 1st April 1853. Rs. Cr:

Expenditure.	Amount	Total.
By Amount paid for Labor during the month of March 1853 as per Daily Accounts Viz.		
Nos 1 Earthwork	3038 10 8	
2 Do.	2805 3 10	
3 Do.	3842 .. 3	
4 Do.	42 2 ..	
5 Do.	37 11 ..	
6 Do.	802 4 5	
7 Do.	477 10 3	
8 Do.	913	
9 Do.	181 .. 4	
10 Do.	221 13 11	
11 Do. (dressing Slopes)	310	
12 Plantations	1 13 8	
13 Brick Kilns	1 15 8	
14 Lime do	1 3 ..	
15 Charcoal do	1 2 ..	
16 Mo. Do.	.. 2 3	
17 Masonry	18 3 6	
18 Timber	20	
By Regular Establishment for March 1853	10	
" Fluctuating Do. Do.	144	
" Purchase of Country Paper	2	
Repair of Banks Contract 20 Miles at 30 per mile	600	17,532 3 7
Balance in hand		2,467 12 5
Total		20,000 .. ..

Over leaf

Daily Account of Expenditure on the [illegible] during the month of March 1833.

	No. 1		No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
	Excavation. 15th Mile.		Excavation 16th Mile.	Spreading [illegible]	Excavation 16th Mile.	Excavation 17th Mile.	Excavation Roorkee Banks.	Spreading [illegible] Sand.	Remarks [illegible]

Date and Description	Amount	Total
Males @ 6 p.	338 " "	
Bildars @ 4 p.	4,500 10 8	
Coolies @ 2 p.	3200 " "	8038 10 8
[illegible]	2000 " "	
[illegible]	150 " "	
[illegible]	4 13 2	2154 13 2
		10,192 13 10
Males @ 6 p.	107 2 10	
Bildars @ 4 p.	2198 " "	
Coolies @ 2 p.	500 " "	2805 2 10
[illegible]	600 " "	
[illegible]	1 13 3	601 13 3
		3,407 1 1
Males @ 6 p.	200 8 3	
Bildars @ 4 p.	3641 " "	
[illegible] @ 2 p.	" 8 "	3,842 " 3
Bildars @ 2 p.		42 2 "
Bildars @ 2 p.		37 11 "
Bildars @ 4 p.	14 5	
[illegible] @ 2 p.	201 6 0	202 4 5
Males @ 6 p.	5 6 8	
Bildars @ 2 p.	472 4 "	477 10 8
Bildars @ 2 p.		212 " "

Date	No. 1		No. 2		No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
1	57 1196 660	1000 [illegible]	18 550 100	2	34 917 1	37	11	1 231	1 168	7½
2	57 1196 660	" "	18 550 100	"	34 910 1	10	10	1 206	1 121	5½
3	57 1196 660	" "	18 550 100	"	34 910 1	10	"	1 206	1 121	5½
4	57 1196 660	" "	18 550 100	"	34 910 1	10	10	1 206	1 121	5½
5	57 1196 660	" "	18 550 100	"	34 910 "	10	10	1 206	1 121	5½
6	57 1195 660	" "	18 550 100	"	34 910 "	10	10	1 206	1 121	5½
7	57 1195 660	" "	18 550 100	"	34 910 "	10	10	1 206	1 121	5½
8	57 1195 660	" "	18 550 100	"	34 910 "	10	10	" 206	1 121	5½
9	57 1195 660	" "	18 550 100	"	34 910 "	10	10	" 206	1 121	5½
10	57 1195 660	" "	18 550 100	"	34 910 "	10	10	" 206	1 121	5½
11	56 1195 660	" "	18 550 100	"	34 910 "	10	10	" 206	1 121	5½
12	56 1195 660	1000 4	18 550 100	2	34 910 "	10	10	" 206	1 121	5½
13	56 1195 660	" "	18 550 100	2	34 910 "	10	10	" 206	1 121	5½
14	56 1195 660	" "	18 550 100	"	33 910 "	10	10	" 206	1 121	5½
15	56 1195 660	" "	18 550 100	"	33 910 "	10	10	" 206	1 121	5½
16	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
17	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
18	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
19	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
20	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
21	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
22	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
23	56 1195 660	" "	18 549 100	2	33 910 "	10	10	" 206	1 121	5½
24	56 1195 660	1000 "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
25	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
26	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
27	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
28	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
29	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
30	56 1195 660	" "	18 549 100	"	33 910 "	10	10	" 206	1 121	5½
31	56 1195 660	750 "	18 549 100	15	33 910 "	10	10	" 206	1 121	5½
	1766 36980 19840	3750 2.16.12	554 17035 3100	67.5	1036 28217 4	337	307½	[illegible] 6411	[illegible]	196

1,120,306 [illegible] feet of Excavation, 258 [illegible] feet taken from 15th Mile of Excavation [illegible] into Ballast Line and [illegible] in [illegible] for a Railway the [illegible] [illegible] an average distance [illegible] the [illegible] of Road [illegible] 10,776 feet [illegible] 10,[illegible] feet.

2880 [illegible] [illegible] feet [illegible] Spread.

...rks of the Northern Division Ganges Canal
Roorkee. 1st April 1853.

Plantation	Mohunpoor Brick Kiln	Lime Kiln at Roorkee	Charcoal Kiln at Roorkee	Charcoal Kiln at Muhubbutpoor	Syneeas Bridge	Roorkee

3000 cubic feet of Masonry work in Wing walls & foundations.

Bill of Establishment attached to the Northern Div. of the Ganges Canal during the month of March

Roorkee 1st April 1853.

...ription	Names	amount	Total	Nature of Establishment
...adu	Ayram		10 " "	Permanent
...i	Yaloo	20 " "		
...adu	Jaffer Ali	15 " "		
	Brij Lal	3 " "		
	Saadut Ali	7 "		
...nasee	Hulloo	5 " "		
	Jehangir Khan	5 " "		
	Sahib Singh	5 " "		
	Heera Singh	5 " "		
	Umer	5 " "		
	Dowlut Ram	5 " "		
	Debee Singh	5 " "		
	Rutton Singh	5 " "		
	Radha ...	5 " "		
	Pujuth	5 "		
...	Sallan	4		
	Ooo	4		
	Debee	4		
	Garai	4		
	Heera Lall	4		
	Bunda Khan	4		
	Salim	4		
	Ganga Ram	4		
	Ram Lal	4		
	Pooran	4		
	Ramdeen	4	144 " "	Fluctuating
...13	Total Co's Rs		154 " "	

16

The above men were paid in my presence.

(Sd) ______

Overseer

Daily Account of Expenditure on the under mentioned [illegible] of the Northern [1st] Division Ganges Canal.

[illegible] month of April 1853. [illegible] [ending] 1st May. 1853.

£ 75: V.m.

Solani Aqueduct [illegible] Plain Masonry

Solani Aqueduct [illegible] Masonry

Solani Aqueduct [illegible] Plain Arch Masonry

Lions

Lions

291,379 C[ubic] feet Masonry.

Mortar

[illegible]

108,342 C[ubic] f[ee]t of Mason[ry]

Mortar

[illegible]

48,242 C[ubic] f[ee]t of Masonry in Arches.

Mortar as before.

11,734 C[ubic] f[ee]t of Plain Masonry in [illegible] pedestals of Lions.

Mortar as before

Bodies of Lions.

[illegible]

Daily Report of Expenditure on [illegible] Eastern Division Ganges Canal, during the month of April 1855.

Roorkee 1st May 1855

Day								
1	200	375 2 314	1 106	2 246	85	11	1	
2	98	375 2 314	1 106	2 246	85	11	1	
3	"	375 2 314	1 106	2 246	85	11	1	
4	"	375 2 314	1 106	2 246	85	11	1	
5	"	375 2 314	1 106	2 246	85	11	1	
6	"	375 2 314	1 106	2 246	85	11	1	
7	"	375 2 314	1 106	2 246	85	11	1	
8	"	375 2 314	1 106	2 246	85	11	1	
9	"	375 2 314	1 106	2 246	85	11	1	
10	"	375 2 314	1 106	2 246	85	11		
11	"	375 2 314	1 106	2 246	85	11		
12	"	375 2 314	1 106	2 246	85	11		
13	"	375 2 314	1 106	2 246	85	11		
14	"	375 2 314	1 106	2 246	85	11		
15	"	375 2 314	1 106	2 246	85	11		
16	"	375 2 314	1 106	2 246	85	11		
17	"	375 2 314	1 106	2 246	85	11		
18	"	375 2 314	1 106	2 246	85	11		
19	"	375 2 314	1 106	2 246	85	11		
20	"	375 2 314	1 106	2 246	85	11		
21	"	375 2 314	1 106	2 246	85	11		
22	"	375 2 314	1 106	2 246	85	11		
23	"	375 2 314	1 106	2 246	85	11		
24	"	375 2 314	1 106	2 246	85	11		
25	"	375 2 314	1 106	2 246	85	11		
26	"	375 2 314	1 106	2 246	85	11		
27	"	375 2 314	1 106	2 246	85	11		
28	"	375 2 314	1 106	2 246	85	11		
29	"	375 2 314	1 106	2 246	85	11		
30	"	375 2 314	1 106	2 246	85	11		
Totals	298	[illegible]	[illegible]	60	[illegible]	2570	[illegible]	

[illegible]

75	84	108	1	3 170
Totals 2250	2520	3240	30	90 5100

127,000 Cubic feet of Miscellaneous Masonry. [illegible]

[illegible]

Supt.

Superintendent.

[P]ay Bill of Establishment attached to the Northern Division [of] Ganges Canal Works during the month of April 1853.

Roorkee 1st May 1853.

[Des]cription	Names	Amount	Total	Nature of Establishment.
[illegible]	Pooten	25 " "		
[illegible]	Koosheal Singh	10 " "		
[Chu]prassie	Ramdeen	6 " "	41 " "	Permanent.
[illegible]	Heera Singh	12 " "		
[illegible]	Thakoordass	12 " "		
	Ram Singh	12 " "		
	Ukbur Ali	12 " "		
	Imam Ali	12 " "		
[illegible]	Dewan Singh	10 " "		
	Iftekhar Ali	10 " "		
	Wuzeent Ali	10 " "		
	Imam-ood-deen	10 " "		
	Aman Khan	10 " "		
[Chu]prassie	Bhawanee Lal	5 " "		
	Seedan	5 " "		
	Ellahee Buksh	5 " "		
	Imam Buksh	5 " "		
	Noor Ilahi Buksh	5 " "		
	Mahumdee Khan	5 " "		
[illegible]	Lyhal	4 " "		
	Ram Singh	4 " "		
	Gungaram	4 " "		
	Gungadeen	4 " "		
	Nebbi Buksh	4 " "		
	Govind	4 " "		
	Huzzaree Lal	4 " "		
	Nuttoo Khan	4 " "		
	Wuzeer-ood-deen	4 " "		
	Lutfoolla Khan	4 " "	180 " "	Fluctuating.

Total Co.'s Rs. 221 " "

[T]he above men were paid in my presence.

(Sd.) ______ Lieut.
2nd Superintendent.

Appendix X.

Supplemental ——— Accounts

for the month of

April [illegible].

Lieutenant ———— Dy. Superintendent in a/c
Ganges Canal for the month of April

Dr.

Date	Receipts	Amount
April 1	To Balance in hand	
10	To Cash received from the Superintendent	1,000 " "
15	Do. Do.	15,000 " "
16	Do. Do.	5,000 " "

Total Co.'s Rs. ——

with the Superintendent of the Northern Division

Roorkee 1st May 1853

Expenditure	Amount	Total
By Amount paid for Labor during the month of April 1853, as per Weekly Report Abst		
No 1 Earthwork	291 " 3	
" 2 Clearance	92 11 9	
" 3 Masonry	3399 14 9	
" 4 Earthwork	26 5 11	
" 5 Masonry	2778 15 3	
" 6 Brick Burning	284 2 6	
" 7 Masonry	1230 2 11	
" 8 Do	330 " "	
" 9 Do	608 14 10	
" 10 Earthwork	37 4 "	
" 11 Earthwork	4210 7 9	
" 12 Earthwork	433 11 6	
" 13 Do	870 " 3	
" 14 Do	321 4 "	
" 15 Do	45 2 1	
" 16 Do	7 9 8	
" 17 Do	19 " "	
" 18 Do	312 4 "	
" 19 Masonry	2505 " "	
By Establishment employed on Masonry works	7 " "	
" Rent of Houses as Store in Lower Branch	25 " "	
" Contract carriage of Bricks at Aqueduct	500 " "	
" Paid Contract for building Work proposed houses	2081 5 10	
" Purchase of Country paper and Ink	2 " "	22,432 9 2
Balance in hand		2,567 6 10
Total Cost		25,000 " "

Appendix B.

Office Account Current with
Overseer ____________
for the month of February 1853.

——— Overseer in Account Current ...

Dr. Division of the Ganges Canal for the ...

Date		Receipts.	Amount
Feby	1	To Balance of last account ———	
	15	To Cash received from the Superintendent —	5000 " "
	24	Do. Do. ———	4000 " "
		Total Cash ———	

Roorkee
1st March 1853.

…tain A. G. Goodwyn Superintendent of the Northern …
… February 1853.

Cr.

Expenditure

	Amount.	Total.
By Tilani Earthen Aqueduct as per Daily Report. Vizt		
Expended on No. 1 Excavation — 1816 3 5		
2 Do — 1967 11 "		
3 Do — 719 12 6		
4 Spreading — 1117 8 8		
5 Excavation — 338 6 4		
6 Spreading — 190 12 5		
7 Removing Sand — 40 10 4		
8 Spreading — 269 " "		
9 Puddling — 904 6 4	7564 7 "	
By expense incurred on the undermentioned works, as per Daily Report. Vizt		
No. 10 Plantations	10 " "	
" 11 Brick Kiln at Muhewar	20 " "	
" 12 Do at Roorkee	50 " "	
" 13 Lime Kiln at Myapoor	10 " "	
" 14 Repairing Bank	20 " "	
" 15 Iron Work of Gates	5 " "	
" 16 Repairing Kussona Chokee	57 4 10	
By Regular Establishment for February 1853	10 " "	
" Fluctuating Do Do	144 11 1	
" Purchase of Country paper	1 " "	7.872 6 11
Balance in hand		2.127 9 1
Total Rupees		10.000 " "

E. E.   Sd/

Head Clerk.

No. 11

Appendix B

[illegible] Account with [illegible] 13

Overseer ____________

for the month of March 1853.

Cash in Account Current with

Cash transactions during the month of Ma[rch]

Date	Receipts	Amount
March	To Balance of last Account	[illegible]
16	To Cash received from the Superintendent	5,000
15	" Do Do	1000

Total Rs

[illegible] 1st April 1853

... Superintendent ... Division &c

...3. &c:

Expenditure		Amount.	Total.
... as per Daily Report ...			
Expended on No. 1	Excavation	10192 12 10	
2	Do.	3407 1 1	
3	Spreading	3842 .. 3	
4	Excavation	422 2 ..	
5	Do.	37 11 ..	
6	Do.	802 4 5	
7	Spreading	477 10 8	
8	[illegible]	212	
9	Spreading	137 .. 4	
10	Ramming	221 13 11	
11	Dressing [illegible]	100	19486 9 4
Expended ... on the undermentioned Works as per Daily Report ...			
No. 12 [illegible]		30	
" 13 [illegible]		50	
" 14 [illegible]		25	
" 15 [illegible] Do.		25	
" 16 Do. [illegible]		20	
" 17 [illegible] Bridge		214 4 10	
" 18 [illegible]		132 8 ..	
By Regular Establishment for March 1863		10	
" Fluctuating Do. Do.		144	
" Purchase of Country paper		2	
" Repair of [illegible] 25 per mile		600	1352 12 10
			20839 6 4
Balance in hand			4160 9 8
Total			25,000 .. ..

C.E. [illegible]

Head Clerk

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Appendix B

Office Account Current with the

2nd Superintendent

for the month of April 1853.

Lieutenant ———— Dr Superintendent in O[f]

Dr — Ganges Canal for the month of April 1853.

Date		Receipts	Amount
April	1	To Balance of last Account ————	[illegible]
	10	To Cash received from the Superintendent ———	1,000 .. ..
	15	" Do Do Do ————	15,000 .. ..
	"	" 10 Lakhs of Brick, received @ 1000/- per lakh ———	10,000 .. ..
	16	" 40 Do Do @ Do ————	40,000 .. ..
	"	" Cash received from the Superintendent ———	5,000 .. ..
	20	" 1,00,000 Maunds of Stone Lime @ 20/- per 100 mds ———	20,000 .. ..
	"	" 1,25,000 Maunds of Soorkee @ 12/- per do ———	15,000 .. ..

Total Co's Rs ————

Posted ...
May 1853

[illegible] with the Superintendent of the Northern Division

'26 Cr:

Expenditure		Amount	Total
By Solani Aqueduct Revetments and Earthwork as per Daily Report: Viz:			
1st. Excavation for foundations	291 " 3		
2. Clearances	92 11 9		
3. Plain Masonry	44,696 6 10		
4. Ramming	26 5 11		
5. Step Masonry	17,181 4 3		
6. Dressing Cut Stones	284 2 5		
7. Main Arch Masonry	7,703 11 9		
8. Masonry of Piers	2,951 9 3		
9. Do Do	1,650 13 4		
10. Excavation preparatory to plastering	37 4 "		
11. Plastering	6,075 2 3		
12. Excavation	433 11 6		
13. Ditto	870 " 3		
14. Spreading	321 4 "		
15. Excavation	46 2 1		
16. Ditto	7 9 8		
17. Spreading	19 " "		
18. Filling Vaults	312 6 "		
19. Main [illegible] Masonry	19,384 3 4	102,[illegible] 3 10	
By [illegible] employed [illegible]		7 " "	
" " [illegible]		[illegible] " "	
" " Contractor for carriage of Bricks from upper to lower [illegible] of Aqueduct		500 " "	
" " Contractor for [illegible]		2,081 5 10	
" Purchase of [illegible]		2 " "	105,196 9 8
Balance in hand			9,803 6 4
Total Cost			1,15,000 " "

(Sd.)

Head Clerk

Appendix Y.

Monthly Abstract Book.

[illegible] Abstract of Charges — [illegible] Accounts for [illegible]
[illegible] February 1853 [illegible]

Description of Work	Labor	Materials	Total
Excavation 15th Mile	1446 9 8	369 [illegible]	1816 3 5
Do 16th Do	1474 13 10	492 [illegible] 2	1967 11 "
Do Do	662 [illegible] "	57 10 6	719 12 6
Spreading the above	417 8 8	" " "	417 8 8
Excavation [illegible] [illegible]	558 6 4	" " "	558 6 4
Spreading the above	190 12 5	" " "	190 12 5
Removing Sand from Aqueduct	40 10 4	" " "	40 10 4
Spreading	249 " "	" " "	249 " "
Puddling	705 6 4	" " "	705 6 4
Brick Kiln at [illegible]	10 9 4	9 6 8	20 " "
Do at [illegible]	28 13 8	21 " 4	50 " "
Lime Kiln at [illegible]	5 " "	5 " "	10 " "
[illegible] Establishment	" " "	" " "	10 " "
Repairing [illegible]	18 [illegible]	[illegible]	20 " "
[illegible]	" " "	[illegible] "	5 " "
Repairing [illegible]	[illegible]	[illegible]	[illegible] 6 10
Plantations	9 " "	1 " "	10 " "
[illegible]	" " "	" " "	1 " "
Sheds along Establishment	" " "	" " "	[illegible] 11 1

Office Abstract of Orders —— & Accounts for month of March 185[illegible]

No.	Work	Description	Labor			Materials		
B	6	Synabas Bridge	18	8	6	295	12	4
C	4	Excavation 15th Mile	2,038	10	8	2154	3	2
"	"	Do 16th Do	2,805	7	10	617	13	3
"	"	Spreading the Above	3,842	"	3	"	"	"
"	"	Excavation 16th Mile	42	2	"	"	"	"
"	"	Do [illegible] Do	37	11	"	"	"	"
"	"	Do [illegible] Banks	802	4	5	"	"	"
"	"	Spreading [illegible]	477	10	8	"	"	"
"	"	[illegible]	210	"	"	"	"	"
"	"	Spreading	151	"	4	"	"	"
"	"	[illegible]	221	12	11	"	"	"
"	"	[illegible] Pipes	100	"	"	"	"	"
			[illegible]			[illegible]		
M	2	[illegible]	1	13	8	48	"	4
"	3	[illegible] do	1	3	"	23	13	"
"	4	[illegible]	1	3	"	23	13	"
"	"	[illegible]	"	10	8	19	3	4
"	5	Making [illegible]	20	"	"	112	8	"
			[illegible]			[illegible]		
H	1	Repairs [illegible]	"	"	"	"	"	"
"	2	Repairs of Roads	"	"	"	"	"	"
"	3	Plantations	1	15	8	28	"	4
"	4	[illegible] County papers	"	"	"	"	"	"
J		[illegible] Establishment	"	"	"	"	"	"

M, 81, [illegible]

Abstract of Dist. Superintendent's — accounts the Month of April 1852.

Description of Work	Labor	Materials	Totals
Excavation for foundations	291 .. 3	.. .. ..	291 .. 3
Clearance	92 11 9	.. .. ..	92 11 9
Main Brickwork	3399 14 9	39296 8 1	42,696 6 10
Ramming Earth	26 5 11	.. .. ..	26 5 11
Step Brickwork	2778 15 3	14,402 5 ..	17,181 4 3
Turning Centres	284 2 5	.. .. ..	284 2 5
Main Arch Masonry	1230 4 11	6472 6 10	7,703 11 9
Masonry of Piers	350	2,601 9 3	2,951 9 3
Do. Do.	603 14 10	1047 .. 6	1,650 15 4
Excavation preparatory to plastering	37 4 ..	.. .. ..	37 4 ..
Plastering	4210 7 9	1861 10 6	6,072 2 3
Excavations to 9th Mile	433 11 6	.. .. ..	433 11 6
Do. 16th Do.	870 .. 3	.. .. ..	870 .. 3
Spreading the above	321 4 ..	.. .. ..	321 4 ..
Excavation 17th Mile	45 2 1	.. .. ..	45 2 1
Do. Powder Bank	7 9 8	.. .. ..	7 9 8
Spreading the above	19	.. .. ..	19 .. ..
Filling Vaults	312 6 ..	.. .. ..	312 6 ..
Plain and Arch Masonry	2,503	17,081 8 4	19,584 8 4
Carriage of Bricks	.. .. ..	.. .. ..	500 .. ..
[illegible]	.. .. ..	.. .. ..	2 .. ..
Paid [illegible] at Aqueduct [illegible]	.. .. ..	.. .. ..	7 .. ..
Paid to Drivers in [illegible]	.. .. ..	.. .. ..	25 .. ..
[illegible] Works	.. .. ..	.. .. ..	2,041 5 10

(92,)

Appendix C.

Officer General's Account Current with the Hon'ble Com.

The Northern Division Ganges Ca[illegible]

Dr: for the Month of February. 1853

Date	Receipts	Amount	[illegible]
February 1	To Balance of last account		11[illegible]
"	To Amount of Assignment [illegible] drawn by the Accountant NWP on the Saharunpore Treasury		7[illegible]
	Total Receipts		[illegible]

Account Current with the Honorable Company

Cr.

Expenditure	Amounts	Total
By Original Works: Vizt:		
Expended on the Solani Earthen Aqueduct	7564 7 ..	7564 7 ..
By Current Expenses: Vizt.		
Plantations	10	
Ordinary Repairs: Repairing Banks — 20.0.0		
Do Kutcha Pukka — 37.4.10		
Iron work of gates — 5.0.0	62 4 10	
Regular Establishment	10	
Office Contingent Expenses	1	83 4 10
By Sundries Account.		
Fluctuating Establishment		144 11 1
By Mr. Finn: Advances		60000 .. ..
By Materials Accounts: Vizt:		
1 Advances to Timber Contractors	7000	
2 Unburnt Brick Kiln	20	
2 Pokhur Do.	50	
3 Mymapoor Lime Do.	10	7080 .. ..
		74872 6 11
Balance in hand		11127 9 1
Total Co's Rs		86000 .. ..

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The Northern Division Gang Co.pany for the month of March 1853

Date	Receipts	Amounts	
March 1	To Balance of last Account ——		[illegible]
7	To Amount of Assignments [illegible] [illegible] Treasury ——	75 00	[illegible]
	Total ——		[illegible]

... in account Current with the Honorable Com-

Cr:

Expenditure.	Amount	Total
By Original Works, Viz:		
Expended on Solani Earthen Aqueduct (Office)	1 " "	
Expended on the Solani Earthen Aqueduct (Works)	19486 9 6	
Do on [illegible] Bridge	314 4 10	19,801 14 4
By Contingent Expenses, Viz:		
Regular Establishment	[illegible] " "	
Ordinary Repairs: Repairs of Roads	600 " "	
Plantation	30 " "	
Purchase of Country Paper	2 " "	642 " "
By Sundries Account: Fluctuating Establishment	144 " "	
Water Conduit for [illegible] purposes	291 4 5	435 4 5
By Mofussil Advances		40,000 " "
By Materials Account, Viz:		
[illegible] Brick Kiln	50 " "	
[illegible] Lime Kiln	25 " "	
Charcoal Kiln at Roorkee	25 " "	
Do Do at [illegible]	20 " "	
Sundries	132 8 "	
Iron and Miscellaneous Metals	25,000 " "	25,252 8 "
		86,131 10 9
Balance in hand		7,868 5 3
Total Co.'s Rs		94,000 " "

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The Northern Division Ganges [illegible]

Dr: for the month of April 1853.

Date	Receipts	Amount	
April 1	To Balance of last account		12,707
5	To Amount of Allegrement [illegible] dated [illegible] drawn [illegible] Accountant [illegible] on the [illegible] from Treasury	75,000	
	To Mr [illegible]: Amt value of the [illegible] Materials delivered to Supdt Superintendent.		
	50 Lakhs of Bricks @ 1000 — 50,000 .. 0 .. 0		
	100000 [illegible] of [illegible] @ 20 — 20,000 .. 0 .. 0		
	125,000 [illegible] @ 12 — 15,000 .. 0 .. 0	85,000	1,600[illegible]

Total Cash [illegible]

Account Current with the Honorable Com-

Cr:

Expenditures.	Amount.	Total.
By Original Works: Viz.		35
Expended on Solani Earthen Aqueduct (2nd Depôt)	1,02,581 3 10	
Do. Do. (Office)	419 10 2	1,03,000 14 ..
By Current Expenses: Viz.		
Regular Establishment	41	
Office Contingent Expenses	2	43 .. ..
By Sundries: Viz.		
Well Sinking at [illegible]	7	
Presents to Officers in Timber Bank digging	25	
Cost contract of [illegible]	2081 5 10	
Fluctuating Establishment	180	2,293 5 10
By P.W. [illegible] Advances		40,000 .. ..
By Material Account damaged Bricks		500 .. ..
		1,45,837 3 10
Balance in hand		26,870 7 9
Total Cr.		1,72,707 11 7

Appendix. D.

Half Yearly Sayer Account Current.

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Saver Account Current of the ...
L.C. Year ending the 30th April 1853.

To Balance Viz:

Cash	19,300	
Unaffected	1255,000	12[illegible]

To Civil Buildings Remittances Viz

To Amt of 1st Payment drawn by the Accountant M[illegible] on the [illegible] Treasury	75,000	
To [illegible] drawn by [illegible]	75,000	
To [illegible] drawn by [illegible]	75,000	[illegible]

Grand Total C.R.[illegible] —— 1[illegible]

[illegible]
1st May 1853.

Division - Ganges Canal Works for the Half Year

Cr.

By Ganges Canal Works

For Amount expended on the [illegible] of Accounts during the [illegible] ending 31st January 1853 passed by the Military Board on the 1st April 1853 —— 1,00,000 " "

For Bills [illegible] Aqueduct passed [illegible] do do 1st February 1853 —— 1,00,000 —— 2,00,000 " "

By Balance [illegible]

Cash —— 2,[illegible] " "

Insufficient [illegible]

Bills submitted to the Military Board Credit as per last Account —— 2,00,000 " "

And since submitted

[illegible] Aqueduct —— 1,36,[illegible] " "

[illegible] —— 315 " "

2 " Establishment for February 1853 —— 10 " "

3 " Do for March do —— 10 " "

4 " Do for April do —— 21 " "

5 " Ordinary Repairs for February 1853 —— 65 " "

6 " Do Do for March do —— 600 " "

7 " Plantations for February 1853 —— 10 " "

8 " Do March do —— 30 " "

9 " Office Contingent expenses for February 1853 —— 1 " "

10 " Do Do for March do —— 2 " "

11 " Do Do " April do —— 2 " "

3,37,332 " "

[illegible] Bills passed as above —— 2,00,000 " " 1,37,332 " "

[illegible] on account of Original Works —— 5,00,000 " "

[illegible] account of [illegible] —— 4,30,[illegible]2 " "

[illegible] account of [illegible] —— [illegible] " "

[illegible] —— 1,50,000 " " 13,24,[illegible]9 12 "

[illegible] Magazine Stores on hand —— 5,000 " " 12,99,300 " "

Grand Total Co.'s Rs —— 14,99,300 " "

(Signed) A. [illegible] Captain,

Superintendent [illegible] Ganges Canal

Appendix E.

Original War Account Book.

C4 Dr. Solani Earthen Aqueduct Cr.

Date	Description	Amount	Total	Description	
1853					
Feby	To Sundries		3064 7 –	By Bill No. 15 in the Quarter ending 30th April 1853	[illegible]
March	To Sundries	12466 7 4			
	" Cash	1 – –	12467 7 4		
April	To Establishment	10254 3 10			
	" Cash	419 10 2			
	" [illegible] account	2173 5 4			
	" [illegible] account	3303 [illegible] 6	[illegible] 5 10		
	[illegible]		[illegible] 6 4	[illegible]	[illegible]

Detailed explanation of Debits

	Description	Labor	Materials	Totals
[illegible]	Excavation, [illegible] Mile, Wagons drawn by [illegible]			
	[illegible], average distance 8520 feet	1246 9 8	569 7 9	1816 3 5
	Excavation, 15th Mile; Wagons drawn by horses,			
	[illegible] average distance 11500 feet	1474 13 10	492 13 2	1967 11 "
	Excavation, 16th Mile, Wagons propelled by men,			
	[illegible] average distance 7000 feet	668 2 "	51 10 6	719 12 6
	1102, 378 cubic feet in above, [illegible] Spread	1117 [illegible]	" " "	1117 [illegible]
	Excavation [illegible] Banks, wagons propelled by			
	[illegible] average distance [illegible] feet	532 6 4	" " "	532 6 4
	Spreading the [illegible]	190 12 [illegible]	" " "	190 12 [illegible]
	[illegible] Surplus [illegible]			
	[illegible] & depositing [illegible]	20 10 6	" " "	20 10 6
	[illegible] earth already deposited	24 " "	" " "	24 " "
	Puddling [illegible]	704 6 4	" " "	704 6 4
	Totals	6150 5 7	914 1 5	7064 7 "
[illegible]	Excavation 15th Mile, Wagons drawn by horses			
	[illegible] Average distance 10,700 feet	8058 10 8	2133 3 2	10192 13 10
	Excavation 16th Mile, Wagons drawn by horses			
	[illegible] Average distance 10,770 feet	2,805 [illegible] 10	601 13 3	3,407 1 1
	2,865,964 cubic feet in above [illegible] Spread	3,842 " 3	" " "	3,842 " 3
	Excavation [illegible] 16th Mile [illegible]			
	[illegible] feet, [illegible] Spread	42 2 "	" " "	42 2 "
	Excavation [illegible] Mile, Wagons propelled by men,			
	Average distance 5000 feet	37 11 "	" " "	37 11 "
	Excavation [illegible] Banks, [illegible] 1,700 feet	803 6 5	" " "	803 6 5
	301,264 cubic feet in above [illegible] Spread	477 10 8	" " "	477 10 8
	10,785 [illegible] earth [illegible]			
	[illegible] and spread	212 " "	" " "	212 " "
	50,340 cubic feet of earth spread [illegible] feet	161 " 4	" " "	161 " 4
	[illegible]	221 13 11	" " "	221 13 11
	Dressing Slopes [illegible]			
	[illegible]	100 " "	" " "	100 " "
	Totals	16,751 9 1	2736 " 5	19,487 9 6
	[illegible] foundations [illegible]			
	[illegible] Excavation [illegible] foundations [illegible]			
	[illegible] Slopes	291 " 9	" " "	291 " 9
	[illegible] deposits [illegible]	75 11 7	" " "	75 11 7
	[illegible] in [illegible]	6391 11 9	34,952 [illegible] 1	41,694 6 10
	[illegible]			
	[illegible]	24 " 11	" " "	24 " 11
	[illegible] in [illegible]	2778 15 0	14,403 5 "	17,181 4 3
	[illegible] for Drain Arches	924 2 5	" " "	924 2 5
	[illegible]	1230 4 11	6473 6 10	7703 11 9
	Carried Forward	0103 [illegible] 3	60172 3 11	70275 11 2

C4. Dr. [illegible] Earthen Aqueduct. Cr.

Date	Description.	Amts.	Description

B.6. Dr. [illegible] Cr.

18[illegible]3

[illegible] ——— [illegible] ending 30th April 18[illegible] ———

Detailed Explanation of Debits.

Description	Labor	Materials	Total
Brought over	10,103 7 3	6,072 " 11	16,175 11 2
[illegible] foundation and Pedestals of Piers	3[illegible] " "	[illegible] 7 2	2,731 7 3
[illegible] Piers in progress	603 14 10	1,047 " 6	1,650 15 4
[illegible] preparation [illegible] and [illegible] filling the same	87 4 "	" " "	87 4 "
[illegible] feet [illegible]	4,210 ; 7	1,861 10 6	6,072 2 3
Excavation, [illegible] Mile Wagon, drawn by horses, [illegible] average distance [illegible] feet	[illegible] 11 [illegible]	[illegible] 7 1	[illegible]90 2 7
Excavation, [illegible] Mile Wagon, as before [illegible] distance [illegible] feet	770 " [illegible]	[illegible] 9 1	1,133 2 6
[illegible] in last 2 [illegible]	321 4 "	" " "	321 4 "
Excavation, [illegible] Mile Wagon [illegible] distance 5,100 feet	[illegible] 2 1	" " "	[illegible] 2 1
Excavation [illegible] same [illegible] distance	7 9 8	" " "	7 9 8
[illegible] feet in last 2 [illegible]	17 " "	" " "	17 " "
[illegible]	312 6 "	" " "	312 6 "
[illegible]	[illegible] "	17,0[illegible] 4	17,[illegible]84 8 4
Totals	[illegible] 2 [illegible]	[illegible] 10 8	103,[illegible] 14 "

[illegible] —— 1[illegible]73 [illegible] 4

[illegible] —— [illegible] 2 6

Description	Labor	Materials	Total
[illegible] foundation and [illegible] Bridge	18 [illegible] 6	2,[illegible] 12 4	[illegible] 14 4 10

Appendix. F.

Side Account Book

Dr. **M 1** Timber

1853 To Balance — 100,000

February To [illegible] — 7,000

Total Cost — 107,000

Dr. **M 2** Bri[ck]

1853 To Balance — 100,000

February To [illegible] — 20 " "
" [illegible] do — 50 " " 7[illegible]

March [illegible] — [illegible]

April To [illegible] — 300 " "
" [illegible] — 60,000 " " 51,[illegible]

Total Cost — 150,[illegible]

Dr. **M 3** Pin[e]

1853 To Balance — 50,000

February To [illegible] — [illegible]

March To [illegible] — [illegible]

April To [illegible] — 20,000

Total Cost — 7[illegible]

Dr. **M 4** Cha[illegible]

1853 To Balance — 100

March To [illegible] — 25 " "
[illegible] — 20 " " [illegible]

Total Cost — 1[illegible]

Dr. **M 5** Sa[illegible]

1853 To Balance — 5[illegible]

March To [illegible] @ 12/ — 15[illegible]

April To [illegible] do — 15,[illegible]

Total Cost — 15,[illegible]

Dr. **M 6** Iro[n]

1853 To Balance — 9,000

March To 2000 [illegible] @ 8/ — 16,000 " "
" 1000 " " [illegible] do " 9/ — 9,000 " " 25,000

Total Cost — 34,[illegible]

ccount | Cr.

By Lime Account	5 " "	
" Brick do.	1 " 4	6 " 4
By Carriage Account		22 14 "
By Solani Aqueduct Work[illegible]		360 " "
By Balance		10,291 1 8
Total Costs		10,000 " "

ccount. | Cr.

By Ordinary Repairs Account		5 " "
By Syphon's Bridge	202 [illegible] "	
" Carriage Account	112 [illegible] "	315 " "
By Solani Aqueduct Work[illegible]		51,500 " "
By Balance		98,900 " "
Total Costs		150,420 " "

ccount | Cr.

By Ordinary Repairs Account	22 8 "
By Syphon's Bridge	51 " "
By Solani Aqueduct Work[illegible]	11,936 " "
By Balance	56,025 8 "
Total Costs	70,030 " "

count. | Cr.

By Balance	1045 " "
Total Costs	1045 " "

ccount | Cr.

By Ordinary Repairs	4 12 10	
" Syphon's Bridge	10 15 10	
" Solani Aqueduct Work[illegible]	18,682 4 8	18,697 14 4
By Balance		46,434 9 8
Total Costs		65,132 8 "

ccount | Cr.

By Ordinary Repairs account	4 8 "
By Balance	33,995 8 "
Total Costs	34,000 " "

Dr. M7 Live St[illegible]

1853 To Balance —————————— 50.00

[illegible] —————————— 50[illegible]

Dr. M8 Miscella[illegible]

1853 To Balance —————————— 500[illegible]

[illegible] —————————— 500[illegible]

ccount. 60 Cr:

By Plantation Account — 772 13 2

" " Do. Do. — 2600 " " 3,372 13 2

By Balance — 46,627 2 10

Total Cost, — 50,000 " "

ccount. Cr:

By [illegible] Account — 131 " 3
" Plantation Account — 1 " "
" Brick Do. — 19 " 8
" Ordinary Repairs Do. — 1 " 8 172 11 7

By [illegible] — 157 7 11
" Chancery Account — " 2 4
" Lime Do. — 23 13 "
" Brick Do. — 38 " 4
" Plantation Do. — 22 " 4 257 7 11

By [illegible] Account & [illegible] — 313 11 10

By Balance — 39,254 " 8

Total Cost, — 40,000 " "

Appendix. G.

Miscellaneous Accounts Book:

Dr. N 1. — Regul[illegible]

1853					
February	To [illegible] — [illegible] for Establishment	10	"	"	
" "	To [illegible] — [illegible] Do. Do.	10	"	"	
April	To [illegible] — [illegible] Do. Do.	[illegible]	"	"	

Dr. N 2. — Ordina[illegible]

1853					
February	To One Mile of Embankment Repairs	20	"	"	
	" Repairs of Regulating Bridge [illegible]	5	"	"	
	" Do. [illegible]	37	4	10	[illegible]
March	To Contract Repairs of Banks 20 Miles a 30/				[illegible]
	Total Cost [illegible]				[illegible]

Dr. N 3. — Plan[illegible]

1853					
February	To planting 300 [illegible] of 1000 Trees	10	"	"	
March	To 300 [illegible] 1000 Young Plants planted	20	"	"	[illegible]

Dr. N 4. — Con[illegible]

1853					
February	To [illegible] Quires Country paper	1	"	"	
March	To [illegible] Quires Do.	2	"	"	
April	To purchase of Country pens and ink	2			[illegible]

Dr. F. — M[illegible]

1853					
	To Balance				1000[illegible]
February	To Advances	60,000	"	"	
March	" Do.	40,000	"	"	
April	" Do.	40,000	"	"	[illegible]
	Total Cost [illegible]				[illegible]

Dr. T. — [illegible]

1853	To Balance	500[illegible]
	Total Cost [illegible]	500[illegible]

Dr. S. — Sun[illegible]

1853					
February	To Fluctuating Establishment				[illegible]
March	To Do. Do.	444	"	"	
	" Well at Aqueduct for [illegible] people	291	4	5	[illegible]
April	To Fluctuating Establishment	180	"	"	
	" Cost Contract of [illegible] Houses at Aqueduct	2113	5	10	[illegible]
	Total Cost [illegible]				[illegible]

...stablishment 25 Cr.

By Current Bill No. 2 of 1853 for Establishment	10 " "		
By Do Do No. 3 do do do	10 " "		
By Do Do No. 4 do do do	41 " "	61 " "	

...pairs Cr:

By Current Bill No. 5 of 1853 for Ordinary Repairs	62 4 10		
Do Do No. 6 Do Do Do	600 " "	662 4 10	
Total Cost Rs		662 4 10	

...ecount Cr:

By Bill No. 7 of 1853 for Plantations	10 " "		
Bill No. 8 Do Do Do	30 " "	40 " "	

...ncies Cr:

By Bill No. 9 for 1853 for Office Contingent expenses	1 " "		
By Bill No. 10 do do do	2 " "		
By Bill No. 11 do do do	2 " "	5 " "	

...ount Cr:

By 20 Lakhs 2½ pukka Bricks, at ...	50,000 " "		
" 100,000 Maunds Stones Lime ...	20,000 " "		
" 125,000 Do Surkee ...	15,000 " "	85,000 " "	
By Balance		1,55,000 " "	
Total Cost Rs		2,40,000 " "	

...ccount Cr:

By Solani Earthen Aqueduct		3,323 2 6	
By Balance		46,676 13 6	
Total Cost Rs		50,000 " "	

...count Cr:

By Solani Earthen Aqueduct		2,873 5 4	
Total Cost Rs		2873 5 4	

Appendix H.

Church Books

Dr. Account

1853			
February	To Bills	100,000	
April	To Bills	100,000	2,000,000
	To Balance		12,77...
	Total Cost		14,97...

Dr.

1853			
February	To Balance		3,000,000
	To General Expenses	83 . 6 . 10	
March	To General Expenses	624	
April	To General Expenses	43	
	To General Wages	136,563 . 11 . 2	136,...
	Total Cost		3,5...

Dr.

1853	To Balance		10,000
February	To Account ...	75,000	
March	Do. Do.	75,000	
April	Do. Do.	75,000	2,25...
	Total Cost		2,2...

Dr.

1853			
February	To Sales	33 . 7 . 4	
	Arrears	38 . 13 . 6	
	Overgoes	11	
March	To Sales	1 . 15 . 8	
	Arrears	28	
	Overgoes	612	
April	To Cash Account	41	
	Pay Superintendent	2	
	Total Cost		

W. T. — 37 — Cr:

By Balance		12,74,300 " "
By Cash	75000 " "	
"	75000 " "	
"	75000 " "	2,25,000 " "
Total Credit		14,99,300 " "

…ount. — Cr:

By Assistant, W. [illegible]	100,000 " "	
By Assistant [illegible]	100,000 " "	200,000 " "
By Balance		137,332 " "
Total Credit		337,332 " "

…ount — Cr:

By Overseer	9000 " "	
" Mr. Finn	60000 " "	
" Boxes	7000 " "	76,000 " "
By Labor	1 " "	
" Mr. Finn	40,000 " "	
" Overseer	15,000 " "	
" Sundries	291 4 5	
" Boxes	25,000 " "	80292 4 5
By Superintendent	21,000 " "	
" Mr. Finn	40,000 " "	
" Sundries	100 " "	
" Original Work	511 10 2	
" Current Expenses	41 " "	61,652 10 2
By Balance		17,067 1 5
Total Credit		235,000 " "

…ment

By Bills	83 4 10	
By Bills	642 " "	
By Bills	43 " "	768 4 10
Total Credit		768 4 10

Dr. — Supt. Superintendent

1853			
	To Balance		400
April	To Cash		210
	Total Cost		[illegible]

Dr. — [illegible]

1853			
	To Balance		100
February	To Cash	60,000	
March	" Do.	40000	
April	" Do.	40000	[illegible]
	Total Cost		240

Dr. — Mr. Cooper

1853			
	To Balance		[illegible]
February	To Cash		[illegible]
	Total Cost		[illegible]

Dr. — Mr. Cooper

1853			
	To Balance		[illegible]
March	To Cash		[illegible]
	Total Cost		[illegible]

Dr. — L[illegible]

1853			
February	To [illegible]		[illegible]
March	To Cooper / Cash	[illegible]	[illegible]
April	To [illegible]		[illegible]
	Total Cost		[illegible]

Dr. — Magazine

1853			
	To Balance		[illegible]

ount — Cr:

By Labour	17,517 2 4	
" Sundries	2,113 5 10	
" [illegible]	500 " "	
" Current Expenses	2 " "	22,432 7 2
By Balance		2,567 6 10
Total Cost		25,000 " "

ccount — Cr:

By [illegible]	90,000 " "
By Balance	150,000 " "
Total Cost	2,40,000 " "

ccount — Cr:

By Labour	6,752 5 11	
" Current Expenses	11 " "	
" Sundries	122 11 1	6,886 1 "
By Balance		2,413 15 "
Total Cost		9,300

By Labour	16,776 3 7	
" Current Expenses	412 " "	
" Sundries	144 " "	17,332 3 7
By Balance		2,667 12 5
Total Cost		20,000 " "

ount — Cr:

By Original Works	6,620 " "	
" Current Expenses	55 " "	
" [illegible]	44 7 "	6,720 " 11
By Original Works	16,540 1 "	
" [illegible]	57 2 4	
" Current Expenses	1 15 8	16,177 3 7
By Original Works		17,517 3 4
Total Costs		43,322 12 10

es — Cr:

By Balance	5,000 " "

Dr. Origi[illegible]

1852.	To Balance			
February	To Sales	6650	8	7
	" Boxes	910	1	8
March	To Sales	11,750	1	7
	" Shares	3,051	12	9
April	To Cash	417	10	2
	" Sales	17,217	3	4
	" [illegible]	82,764	4	6
	" [illegible] Account	2,273	3	4
	" [illegible] Account	3,323	2	6
	Total [illegible]			

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Dr. [illegible]

1852	To Balance			
February	To Cash	1,000	"	"
	" Sales	44	9	"
	" [illegible]	86	7	"
March	To Cash	25,000	"	"
	" Sales	86	2	4
	" [illegible]	227	5	8
April	To [illegible]	500	"	"
	" [illegible]	65,000	12	1
	Total [illegible]			

Dr. Sund[illegible]

1853				
February	To [illegible]			
March	To [illegible]	[illegible]		
	" Cash	271	4	5
April	To [illegible]	2,113	6	6
	" Cash	180	"	"
	Total [illegible]			

Dr. T[illegible]

1853	To Balance			
	Total [illegible]			

...nts | | Cr:

By Bills				136563 11 2
By Balance				500000 " "
Total Credits				636563 11 2

...ount | | Cr.

By Original Works	911 1 5			
" Current Expenses	30 13 6			
" Stores	36 7 "			788 4 11
By Original Works	3051 12 9			
" Current Expenses	28 " 4			
" Stores	227 5 8			3307 2 9
By Original Works				82764 " 6
By Balance				430772 4 10
Total Credits				517832 8 "

...ount | | Cr.

By Original Works	2873 5 4
Total Credits	2873 5 4

...ount | | Cr:

By Original Works	3323 6 6
By Balance	46676 13 6
Total Credits	50,000 " "

Dr. —— Balance Sheet ——

"	"	"	Accountant Mr. [illegible]	12,9[illegible]
13,302	"	"	Bills Account	
17,067	1	5	Cash Account	
2,567	4	10	[illegible] Superintendent's Account	
2,415	15	"	Mr. Oreson [illegible] Account	
2,467	12	5	Mr. Oreson [illegible] Account	
1,55,000	"	"	Mr. James [illegible] Account	
5,000	"	"	[illegible] Account	
4,30,772	14	10	[illegible] Account	
5,00,000	"	"	Original Stock	
46,676	13	4	[illegible] Account	
12,99,300	"	"	Total	12,9[illegible]

To 4th Quarter ending 30th April 1853

Northern Division Ganges Canal

Bill — No. 15

The Honorable Company — Dr.

To the following expenditure incurred in the par[illegible] construction of [illegible] Aqueduct with Masonry [illegible] during the Quarter ending 30th April 1853, being part of the [illegible] Colonel Cautley's Report [illegible] and [illegible] Estimate of 1850 [illegible]

Roorkee 1st May 1853.

Items of Expenditure	Labor	Materials	[illegible]	Tools	Totals
[illegible] from 14th Mile, Wagons drawn by Horses	1422 9 8	369 9 9	54 1 2	46 12 1	1917 . 8
[illegible] Ditto Ditto Ditto	1,474 13 10	492 13 2	57 13 .	50 6 2	2,075 4 3
[illegible] pushed by men	668 2 .	51 10 6	7 3 2	18 2 10	745 2 6
[illegible] the above 3 Items	1,117 8 8	. . .	8 12 .	28 2 7	1,154 10 2
[illegible] Borrow Banks, wa[illegible] [illegible] pushed by men	330 6 4	. . .	5 4 11	13 9 2	350 4 5
[illegible] the above	190 12 6	. . .	1 8 5	4 13 .	197 1 10
[illegible] of Aqueduct [illegible] deposited in channel	40 6 4	. . .	. 5 3	1 . 5	42 . .
[illegible] already deposited	269 . .	. . .	2 2 5	5 12 5	277 14 10
[illegible] Ditto Ditto	904 4 4	. . .	7 3 9	22 12 9	934 6 10
[illegible] from 15th Mile, Wagons drawn by Horses	8,033 4 8	2154 3 0	282 4 .	262 10 4	10,738 6 2
[illegible] Ditto, Ditto Ditto	2,805 3 10	601 13 3	103 3 1	87 12 1	3,598 . 3
[illegible] the above 2 Items	3842 . 2	. . .	31 3 9	96 13 4	3970 1 4
[illegible] 15th Mile [illegible] in baskets and [illegible]	422 . .	. . .	. 5 4	. 15 3	438 4
[illegible] wagons pushed by men	37 11 .	. . .	. 5 4	1 1 .	38 15 7
[illegible] Banks, Ditto Ditto	803 4 5		" 15 11	20 4 6	831 8 10
[illegible] the above 2 Items	477 10 8	. . .	3 13 3	12 . 7	493 8 6
[illegible] deposited in channel [illegible] to embankments	212 . .	. . .	1 11 2	5 5 6	219 . 8
[illegible] earth already deposited	151 . 4	. . .	1 3 4	3 12 10	156 . 6
[illegible] earth and slopes	221 13 11	. . .	1 12 5	5 9 6	229 3 10
[illegible]	100 . .	. . .	. 12 10	2 8 4	103 5 2
[illegible] foundations of Piers & embankment [illegible] Revetment [illegible]	291 . 3	. . .	2 5 3	7 5 4	300 10 10
[illegible] deposit on Revetment	92 11 9	. . .	. 12 .	2 5 5	95 13 2
[illegible] Masonry	5,399 4 9	3929 6 8 1	995 11 1	1143 1 10	26,835 3 9
[illegible] below [illegible] of Cattle Ghat	22 6 5	. . .	. 3 .	. 9 1	23 2 6
[illegible] Masonry	2,778 15 3	14,402 5 .	383 4 .	439 9 .	18,004 11 3
[illegible] for main arch [illegible]	284 2 5	. . .	2 4 4	7 2	293 9 4
[illegible] Masonry	1230 4 11	6473 6 10	175 3 3	196 14 4	8072 15 4
Carried forward — Co.'s Rs.	32,421 1 6	62,841 5 9	2127 4 5	2,488 2 4	101,949 3 11 4

[illegible] No. 15 — Continued

Description of Work	Labor	Materials	Sundries	Total
Brought forward — Co. Rs.	33,401 [illegible]	63,842 5 [illegible]	2,137 [illegible]	2,438 8 [illegible]
[illegible] cutting [illegible]	3 [illegible]	.. ..	.. 11	.. 1 [illegible]
Plain masonry in foundations & pedestals [illegible]	350 ..	2601 9 3	65 9 2	75 [illegible]
Masonry of bodies of ditto	603 14 [illegible]	1,047 .. 6	36 10 6	42 3 1
Excavation below [illegible] for [illegible] & refilling that excavation	37 4 ..	.. ..	.. 4 9	.. 3 1
[illegible]	4,210 7 9	1861 10 6	135 15 6	155 [illegible]
Excavation from 15th Mile, wagons drawn by Horses	433 11 6	[illegible]	17 14 ..	12 11 3
Do 16th Do Do Do	870 .. 3	[illegible] 3 1	35 15 ..	29 3 7
Spreading the above [illegible]	321 4 ..	.. .. ..	29 ..	8 1 6
Excavation from 17th Mile, wagons pushed by men	452 1	.. .. ..	.. 6 2	1 2 2
[illegible]	79 8	.. .. ..	 3	.. 3 1
Spreading [illegible]	19	.. .. ..	.. 2 5	.. 7 8
[illegible] taken from channel [illegible] wells, and rammed	312 6 ..	.. .. ..	2 6 ..	7 4 ..
[illegible] masonry in [illegible]	2,503	17,081 8 ..	438 1 3	500 9 ..
Grand Total — Co. Rs.	43,197 2 ..	8[illegible]53 12 6	2,878 [illegible]	3,3[illegible]9 2 6

Average [illegible] the above Expenditure.

Channel.

500,[illegible] c. feet	excavation from 15th Mile, filled into Ballast Wagons, propelled along Railway by Horses an average distance of 8540 feet and emptied by side of rail @ Rs 3/13/2 per 100 c. feet	1917 .. 8
3,99,300 Do	from 16th Do filled do and propelled do an [illegible] do do @ Rs 5/[illegible]/2 per do	20[illegible]6 4 3
2,0[illegible],112 Do	Do Do Do propelled along rail by men, do do 7000 feet do do @ Rs 3/11/0 per do	[illegible] 2 6
11,0[illegible],378 Do	in [illegible] items spread in channel @ Rs [illegible] per do	11[illegible]
	Giving aggregate rates as follows: 15th Mile Work [illegible] @ 4/13/11 per 100, 16th Do Do @ Rs 6/3/11 per do, [illegible] Do Do [illegible] @ Rs 4/11/[illegible] per do.	
1,94,[illegible] Do	Excavation from [illegible] Bank, filled into Ballast Wagons, propelled along railway by men an average distance of 5,000 feet and emptied by side of rail @ Rs 2.13.10 per 100 c. feet	55[illegible] 4 5
1,94,525 Do	in last item spread in channel @ [illegible]/3 per do	197 1 [illegible]
	Giving an aggregate rate of Rs 3/14/[illegible] per 100 c. ft.	
1[illegible],250 c. feet	of Surplus Sand removed from top of Aqueduct arches and deposited in channel @ Rs 3/13/0 per 100 c. feet	42 .. ..
1[illegible]5,000 Do	of Earth already deposited in channel [illegible] spread @ Rs 2/[illegible]/11 per do. N.B. This is, generally speaking, shallow digging, finishing off bed [illegible]	277 14 10
	Carried forward — Co. Rs.	6,967 6 9

Brought forward — Co's Rs. — 6,9[illegible] [illegible] 9

[illegible] C. feet of earth already deposited in channel [illegible] at [illegible] @ Rs 3/3/6 per 100 C. feet — 732 6 10 — 7,6[illegible] 13 [illegible]

Embankments

[illegible] C. ft. Excavation from 12th Mile filled into ballast Wagons propelled along railway by bullocks an average distance of 10 [illegible] feet and emptied by side of railway @ Rs 5/[illegible] per 100 C. ft. — 10,738 6 2

[illegible] Do. 16th Do. Do. Do. Do. 10,775 feet and do do @ Rs 2/12/2 per 100 C. ft. — 3,578 . 3

[illegible] Do. in 6 inch layers, clods spread @ Rs 1/[illegible] per do — 3,970 1 4

Forming aggregate rates as follows:

12th Mile, worked by horses Rs 6/6/8 per 100 C. ft.

16th Do. Do. Do. 6/2/2 Do.

[illegible] Do. Do. [illegible] carried in baskets a distance of 160 feet up a height of [illegible] feet and spread in embankments @ Rs 3/[illegible]/10 per 100 C. feet — 23 8 4

[illegible] Do. Do. from 17th Do. filled into ballast Wagons propelled along railway by men an average distance of 5,000 feet and emptied by side of railway @ Rs [illegible]/[illegible]/2 per 100 C. feet — 56 15 [illegible]

[illegible] Do. Do. from [illegible] Banks do do an [illegible] feet and do do @ Rs 2/14/[illegible] per 100 C. feet — 831 3 10

[illegible] Do. in 6 inch layers clods spread @ [illegible]/10/2 per do — [illegible] 8 6

Forming aggregate rates as follows:

17th Mile worked by men Rs [illegible]/[illegible] per 100 C. ft.

[illegible] Banks Do. [illegible]/8/[illegible] Do.

[illegible] Do. earth formerly deposited in channel [illegible] to embankments and spread @ Rs 2/[illegible]/6 per 100 C. feet — [illegible] . 8

[illegible] Do. Do. [illegible] embankments [illegible] @ Rs 3/[illegible]/7 per do — 15[illegible] . 6

Cost of ramming earth round quadrantal [illegible] Steps — [illegible] 3 10

[illegible] C. ft. of Excavation preparatory to dressing Slopes @ Rs 3/ per 100 C. feet — 33 . 6 [illegible]

[illegible] dressing slopes [illegible] @ Rs [illegible] per 100 [illegible] — [illegible] — 10[illegible] [illegible] 2 — 20,21[illegible] 11 [illegible]

Revetments.

Cost of Bailing up water in foundations of Piers together with [illegible] C. ft. of Excavation for foundations of Piers and of Embankment Steps — 300 10 10

Clearance of argillaceous deposit on revetment — 95 13 2

[illegible] C. ft. of plain masonry in Revetments, mortar being equal portions of Lime, Soorkee and Sand @ Rs 16/1/2 per 100 C. feet — 4,[illegible]35 3 9

In aspect of [illegible] Cattle Ghats commenced by [illegible] [illegible] of ramming earth below esplanade of Cattle Ghats — 9[illegible] 4 7

Carried over — Co's Rs — 4,[illegible] . 4 — 28,323 8 9 4

Bill [illegible] — No. 15 — Continued

Brought forward [illegible] — [illegible]

1,08,325 Cft [illegible] masonry in revetments, mortar as before, @ Rs 1[illegible]/1/10 per 100 Cft — 18004 11 [illegible]

[illegible] do [illegible] in [illegible] for main [illegible] — [illegible] 3 7 4

48,242 Cft [illegible] masonry in Revetment, mortar as before @ Rs 16/11/[illegible] per 100 Cft — 807[illegible] 13 4

19,734 Do. plain masonry in foundations and pedestals of lions [illegible] as before @ Rs 15/4/9 per do — 3,092 9 3

Masonry of bodies of Lions in progress — 1,729 12 11

[illegible] in Canal bed for plastering, and [illegible] [illegible] measurements — 38 7 10

1,56,803 Sqft [illegible], 118,171 Sqft being completely finished and remainder being unpolished @ Rs 4/1/2 per [illegible] 100 Square feet — 6363 13 [illegible]

1,24,662 Cft excavation from 13th Mile filled into ballast wagons [illegible] along railway by horses, an average distance of 8540 feet and emptied by side of rails @ Rs 4/12/8 per 100 Cft — [illegible]20 11 10

2,26,215 Do. [illegible] 1650 feet and dadoes @ Rs 5/4/[illegible] per 100 Cft — [illegible]78 5 11

3,50,883 Do. [illegible] spread in Revetment [illegible] and slightly rammed @ Rs 0/13/1 per do — 331 4 [illegible]

[illegible] aggregate rates as follows

[illegible] @ Rs 5/14/9 per 100 Cft

[illegible] Do. Do. Do. [illegible] 6/13/10 Do.

10,800 Cft Excavation [illegible] Mile filled into Ballast wagons, [illegible] by men, an average distance [illegible] feet and emptied by side of rails @ Rs 4/5/1 per 100 Cft — 46 10 [illegible]

[illegible] Do. [illegible] Do. Do. Do. 5,000 feet and dadoes @ Rs 4/[illegible] per 100 Cft — 7 13 [illegible]

[illegible] Do. [illegible] spread in banks and rammed [illegible] @ Rs 1/6/11 per 100 Cft — 1[illegible] 10 1

[illegible] aggregate rates as follows

[illegible] @ Rs 5/[illegible] per 100 [illegible]

[illegible] Do. Do. [illegible] 5/13/[illegible] Do.

[illegible] Cft Earth [illegible] deposited [illegible] & [illegible] banks, and rammed @ Rs 4/13/10 per 100 Cft — 399 15 [illegible]

[illegible] Do. Miscellaneous masonry (chiefly plain) in [illegible] steps, mortar as before @ Rs 16/3/6 per 100 Cft — 20593 2 7

Grand Total — Co's Rs — [illegible]

[illegible] the Rates

Rates		[illegible] in ballast wagons
Last Quarter	Present	drawn by horses. [illegible] at [illegible] quarter [illegible] rate. Last quarter, owing to the
5/14/10 per 100 Cft at 9400 distance 1st August 1852	5/13/2 per 100 Cft at 8540 feet distance	number of horses [illegible] for work, the rates [illegible] higher [illegible] made [illegible] the rates of the quarter ending 31st July, due allowance [illegible] distance being afforded at [illegible] per 100 feet which is [illegible] fair, the present rate
5[illegible] per 100 Cft 11540 distance		

Carried forward — Co's Rs — [illegible]

[illegible]	[illegible] forward — [illegible]	136249 6 4

[illegible] will be [illegible] [illegible] [illegible] [illegible] rate as per [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] ballast Wagons [illegible] [illegible] [illegible]

Spreading Earth in [illegible]. This [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that the Spreaders [illegible] [illegible] [illegible] [illegible] [illegible] ground [illegible] [illegible] that [illegible] [illegible] was [illegible] [illegible] [illegible] that they were [illegible] [illegible] and therefore [illegible] [illegible] [illegible] immediately [illegible] the [illegible]

[illegible] [illegible] ballast Wagons [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] no regard being had to difference of distance.

Puddling earth already deposited. Comparison of rates, here is little more than a game. Distances from which earth already deposited is moved, and facilities for obtaining that earth, vary so much in different localities that great variation of rates, must always exist.

It is not supposed necessary to notice rates of earthwork further.

Carried over — [illegible] — 136249 6 4

[illegible] — No. 15 Continued

Rates: Last Quarter	Rates: Present Quarter	Brought forward —— Co.'s Rs —— 1361[illegible]
1st Augt 1852 15,3,1 per % Cft	16,1,2 per % Cft	Plain masonry cannot properly be compared with the plain and rubble masonry of last quarter the rate of which moreover was then presumed to be incorrect. If however the comparison is made with the plain masonry of Cattle Ghats [illegible] of the Quarter ending 31st July 1852, and it is considered that a rise in the price of Bricks should affect the cost of 100 C. feet of masonry to the extent of 14 as/5, the rates compared will agree within 3 pie of each other. Great part of this quarter's masonry is in bricking out.
1st May 1852 15,3,2 [illegible] % Cft	16,11,9 per % Cft	Arch masonry and Steps is here compared with that in Cattle Ghats than which after making allowance for rise in price of bricks, it is 10 as/3 per % C feet dearer. The difference is due [illegible] to the different quantity of material used, the rate of labor in the present instance being 1/6th lower than before.
[illegible] May 52 15,10,3 per % Cft	16,9,10 per % Cft	Step masonry after due consideration of rise in the price of bricks is within one anna exactly of its proper rate. Last quarter's rate is purposely rejected as incorrect.
	4,1,2 per % Sq feet	Pukka plaster has been executed before on this work as per Bill [illegible] 1st May 1850 @ 5,0,9 per % Square feet, as per Bill [illegible] 1st February 1851 @ 5,0,5 per % do, and as per Bill dated 1st May 1851 at 4.15.4 per % do; but I am sorry that this rate does not afford ground for congratulation, as in addition to the work not being all finished, it is not I confess as well done as before. This will be carefully looked to for the future.

[illegible]

Carried forward —— Co.'s Rs —— [illegible]

Voucher — No. 15 Continued

Brought forward — Rupees — 136249 6 4

Abstract Account.

Rupees received in part of the general assignment for the Ganges Canal Works — 136249 6 4

Do. expended being the amount of this Bill — 136249 6 4

Grand Total — Rupees — One Lakh, thirty six thousand two hundred and forty nine — 136249 0 0

Signed A. G. Goodwyn Lieutenant

The Secretary Military Board Fort William — Ex. Engr. 4th Divn. Ganges Canal Works

I declare upon my honor that the sum in this Bill has been duly expended for the purposes set forth.

(Sd.) A. G. Goodwyn Lieutenant.
Ex. Engr. 4th Divn. Ganges Canal Works.

Abstract.

Extract [illegible] the [illegible] Director [illegible] showing the [illegible] expended and the quantity of work executed on the Solani [illegible] Aqueduct up to the 30th April 1853

Work executed		Expenditure	
Earthwork	Masonry		
of all Sorts	of all Sorts		
Cubic feet	Cubic feet		
460,593,224	243,418,75.062	Up to 31st January 1853	[illegible]
		Captain Goodwyn's Bill, No. 15 for the quarter	
48,95,948.0	5,94,698.0	ending 30th April 1853	[illegible]
509,91,885	2,424,9,36,5,73.062		

Miscellaneous: 7,8 Piles driven.
271610 Sqfeet of Pukka Plaster.
54,79 [illegible] undermining [illegible] Blocks
229,405 Sqfeet [illegible]

Total [illegible] — [illegible]

Comparing the rates [illegible] of the Revised Estimate [illegible]

Earthwork as per Estimate

509,91,885 C. feet of Excavation of all Sorts @ 3/13/3 per [illegible] C. feet — [illegible]
Add 5 per cent [illegible] contingencies — [illegible]
Amount — [illegible]

Earthwork as per Bill

509,91,885 C. feet of Earthwork [illegible] per [illegible] C. feet — [illegible]

Showing an Excess of — [illegible]

Masonry as per Estimate

4,9,2,4,5,73 C. feet Masonry [illegible] @ 16/[illegible] per [illegible] C. feet — 8,02,964 7 [illegible]
Add 5 per Cent contingencies — 40,148 3 [illegible]
Amount — 8,43,112 10 [illegible]

Masonry as per Bill

4,9,2,4,5,73 C. feet of masonry [illegible] @ [illegible] per [illegible] C. feet — 7,36,894 [illegible]

Showing a Saving of [illegible] — [illegible]

[illegible] work [illegible] up to the 30th of April 1853, there is [illegible] — [illegible] —

[illegible] 30th [illegible] 1853 the average rate of the Earthwork was in [illegible] [illegible] per [illegible] and there [illegible] is now [illegible] [illegible] of the Estimate [illegible] the [illegible] the period under review [illegible]

On masonry the average rate has also increased [illegible] per [illegible] [illegible] on the 31st January 1853, but there is still a [illegible] margin when comparing it with the Estimate.

[illegible] to the Board [illegible] Captain Goodwyn's remarks [illegible] [illegible] with former Quarters [illegible] with my approval [illegible] that the [illegible] sanctioned.

Signed P. S. [illegible] [illegible]

Director Ganges Canal Works

To the Quarter ending 30th April 1853.

IInd Div.n Ganges Canal.

[illegible] Report and Statement of Measurements of certain [illegible] executed in the partial construction of an earthen [illegible] work & masonry revetments across the Solani [illegible] during the Quarter ending 30th April 1853.

Roorkee 1st May 1853.

Measurements. Masonry.

[illegible]	L.	B.	D.	Area	No.	Contents	Plain	Tap.	Arch	Ornamental	[illegible]	Plaster
[illegible]	270	3.1	3	"	"	2,498						
	117	"	"	[illegible]	"	1,332						
	16	"	"	21.32	4	853						
	240	"	"	3.2		2,132						
	300	"	"	7.3		2,190						
	1,265	"	"	4.36	"	5,387						
	[illegible]	"	"	12.[illegible]	"	22,518						
						38,190						
[illegible]	3	"	"	13.10	15							
Do.	3	"	"	4.36	10	1,201	36,983					
	200	"	"	5.5	"	1,100						
	640	"	"	18.8	"	12,032						
	350	"	"	9.13	"	3,371						
	93	"	"	3.48	"	324		16,827				
	250	"	"	10.3	"	2,575			2,575			
	375	3.1"	4	"	"	4,625						
	9½	1"	4	"	"	60						
	310	3.9"	1.9"	"	"	2,034						
	250	4.5"	3	"	"	3,313						
	110	4.7"	2.9"	"	"	479						
	110	3.7"	1.9"	"	"	690						
	1,300	"	"	2.6	"	3,380						
	1,250	"	"	1	"	1,250						
	650	3.1"	6.9"	"	"	13,112						
	1,030	3.1"	11	"	"	34,934						
	1,250	"	"	13.1	"	16,375						
	615	3.1"	6"	"	"	794						
	9½	1"	16	"	5	732						
	10	3.1"	7.6	"	2	463						
	10	3.1"	13	"	2	1,202						
	10	"	"	7.06	3	212						
	735	"	"	8.2	"	6,027						
	430	"	"	8.2	"	3,526						
	10	3.1"	6.6"	"	"	170						
	10	"	"	9.6	"	96						
	1,400	"	"	3.86	"	5,404						
	10	3.1"	13	"	"	401						
	10	"	"	7.06	"	71	91,370					
	1,300	"	"	23.93	"	31,109						
[illegible] reported						21,462		9,645				
	1,904	"	"	10.3	"	19,611						
						10,258			9,353			
	280	2	2	"	"	1120						
	683	3.1"	5	"	"	10,530						
	455	3.1"	6.6"	"	"	9,119						
	360	3.1"	6.9"	"	"	7,492						
Forward						28,261	136,259	26,474	1,928			

Measurements. [illegible]

Description	L	B	D	Area	No.	Contents	Plain	Steps	Arch.	Misc.
Bro^t forward						28,261	1,36,359	26474	11,928	
	554	3.1	5.0	"	"	8,541				
	380	3.1	1.0	"	"	1,171	37,973			
fig. P. 105.	270	"	"	8	"	21[illegible]				
	190	"	"	23.93	"	4,547		6,707		
	280	"	"	9	"	2,520				
	657	"	"	10.3	"	6,767			9,287	
	212	3.1	6.8	"	"	4,358				
	190	3.1	6.6	"	"	3,954				
	108	3.1	6.0	"	"	1,998				
	100	"		13.1	"	1,310				
	600	4.3	1	"	"	2,550				
	5	"	"	16.6	6	498	14,668			
	270	"	"	11.11	"	3,000				
	100	"	"	21.18	"	2,118				
	200	"	"	23.93	"	4,786				
	400	"	"	18.	"	7,200		17,104		
	1584	"	"	10.3	"	16,315				
Deduct previously repeated						6,767			9,548	
	558	4.3	1	"	"	2,391				
	1040	4.8	9	"	"	3,315				
	535	"	"	2.94	"	1,573				
	1,250	"	"	1.94	"	2,425				
	25	"	"	16.69	"	415				
	180	"	"	21.32	"	3,838				
	500	"	"	8.22	"	4,110				
	50	3.1	7	"	"	1,079				
	350	"	"	13.10	"	4,585				
	600	"	"	2.6	"	1,560				
	600	"	"	7.06	"	4,236				
	855	"	"	21.32	"	18,229				
	7	1.7	2.6	"	"	35	47,771			
	400	"	"	5.93	"	2,372				
	1,412	"	"	23.93	"	33,789		34,161		
	900	"	"	10.5	"	9,270			9,270	
	1,370	"	"	2.54	"	3,480				
	568	"	"	13.10	"	7,441				
	788	"	"	2.6	"	2,049				
	944	"	"	2.94	"	2,775				
	400	[illegible]	[illegible]		"	925				
	5	"	"	18.12	8	725				
	1170	"	"	7.06	"	8,260				
	863	"	"	21.32	"	18,399				
	651	"	"	13.1	"	8,528				
	498	"	"	2.94	"	1,464				
	10	3.1	[illegible]		3	[illegible]505	54,601			
	915	"	"	23.93	"	21,896		21,891		
	797	"	"	10.3	"	8,201			8,209	
[illegible]	36.4	"	15.5	"	"	5,085				
	[illegible]	[illegible]	9	"	"	144				
	18.6	8.1	29.6	"	"	1,389				
	[illegible]	[illegible]	[illegible]	"	"	59				
	[illegible]	"	[illegible]	"	"	323				
	4	7	2	"	"	56				
					18	7,056				[illegible]
[illegible]	23	11	10.6		4	10,626				
	23	11	7		4	7,108	17,734			
[illegible]	315	4.3	"	1,64[illegible]	"					
	8	9.3	"	74	"					
	646	3	"	161	"					
	648	2½	"	135	"					
	648	1.11	"	240	"					
	648	3	"	162	"					
	647	3	"	162	"					
	646	3	"	161	"					
	646	7½	"	404	"					
	646	1.2	"	753	"					
				3223	3½	19,586				
Carried over						19,586	3,11,106	1,08,342	48,242	[illegible]

Measurements. Masonry.

Description	L.	B.	D.	Area	No.	Contents	Plain	Steps	Arch	Miscellaneous	Rubble Paster
[illegible] over						19,584	3,11,106	1,08,322	48,242	1,27,008	
[illegible]	550'	"	"		2	25,795					
	300	"	"		"	2400					
	312				"	2079					
	100	"	"	"	"	667					
	4	"	"	"	2	54					
	54					486					
	measured above [illegible]				4	1,306					46,587
	350'	5.6	"		"	5562					
	320'	11'	"	"	"	3,520					
	320'	3.8'	"	"	"	1,173					
	10'	9.5	"	"	2	187					
	170'	16.10	"		"	2692					
	170'	8'			"	114					
	320	7'	"		"	2240					
	105'	28..		"	"	2,926					
	100'	6.5		"	"	658					
	104'	6.5	"	"		5?2					
	105'	1.10	"	"	"	2097					
	104'	8.2'	"	"	"	849					23,896
	830'	"	"	7.10	"	3,928					
	1261		"	16.75	"	21,122					
	957'	"	"	5.0	"	4,785					
	2274	"	"	6.87	"	15,622					
	"	"	"	4565.75	4	18,263					65,720
Grand Total Contents							3,11,106	1,08,322	48,242	1,27,008	1,56,203

Excavation &c.

Measurements. Earthwork.

D.	No.	Contents	Chains	Banks	Filling Vaults	Remarks
15'	"	15,000				
5.6"	"	20,790				
16.6	"	3,91,875				
		4,27,665	3,29,066	5,264	93,335	From 13th Mile in horse Wagon distance 8500 feet
17'	"	157,080				
[illegible]	"	12,150				
[illegible]	"	5,166				
13'	"	40,630				
15'	"	9,180				
		2,29,206	52,400	1,76,806	"	[illegible] by men, 6200 dist: and do do in horse Wagons 8500 ft. distance.
15'	"	11,440				
11'	"	18,150				
"	"	12,500				
		47,090				
		4990				
		42,100	20,400	21,700	"	From [illegible] by men, 2250 distance
23'	"	18,520				
9'	"	1,29,330				
14.6"	"	51,200				
16.6	"	1,05,894				
16.6"	"	1,63,372				
5.6"	"	12,980				
		4,81,314	1,48,000	3,28,081	5,233	From 15th Mile in horse Wagons dist: 9000 feet.
5.2'	"	6,187				
14'	"	94,080				
15.6"	"	26,250				
9'	"	11,700				
[illegible]	"	34,550	"	"	1,72,767	From 11th do do do.
Carried over			5,29,866	5,31,851	2,71,335	

Measurement. Earthwork.

L.	B.	D.		Contents	Channel	Road	Filling Vault	Remarks
Brought over					549866	531,851	2,71330	
61'	10'	8'	"	4880				
111'	9	8'	"	7992				
70	30'	2.6"	"	5,250				
40'	10'	5'	"	2000				
180	12	5'	"	10,800			10.300	From 14th Mile by [illegible]
				30,928 {	1,255	15,775	1,822	From Hookes Banks do do.
375'	10	14'	"	52,500				
845	10	9	"	76,050				
940'	5'	13.7"	"	64,625				
460	16	7'	"	51,520				
825'	10'	15'	"	1,23,750				
50	Area	1239	"	61,950				
				4,30,295	23,900	3,80,295	26,100	From 15th Mile in [illegible]
90'	18'	26'	"	42,120				
64'	27'	16'	"	27,648				
150'	43'	16	"	1,03,200				
300	55'	2.6"	"	41,250				
				2,14,218	"	2,14,218		From 16th [illegible]
240	30'	[illegible]	"	51,200				
38'	31'	4.[illegible]	"	5,006				
1[illegible]	11	[illegible]	"	17,608				
271	10	2.6	"	8,130				
271	5	3	"	4,065		12,195 }		From 14th Mile [illegible]
				78,009	39,100	46,714 }	"	From Hookes Banks do do
287'	30'	16'	"	1,37,760				
654	10	14'	"	91,560				
440'	15'	16'	"	1,05,600				
324	30	[illegible]	"	19,440				
700	20'	[illegible]	"	56000				
50	Area	18[illegible]	"	92,550	"	5,02,910	"	From 15th Mile in [illegible]
125	33'	[illegible]	"	1,05,060				
90'	10'	26'	"	23,400				
760'	48'	1.9"	"	64,512				
431	14'	16'	"	51,744				
50'	45'	11'	"	24,750				
167	45'	5.6"	"	41,332				
69	49'	17'	"	40,817				
600'	6.6	5.8"	"	22,857				
50'	12'	9.6"	"	5,700				
50'	Area	179	"	8,950	70,900	3,56,070 {	"	From 16th [illegible] do. do. do.
				3,89,602	60,612	" }	"	Do. Do. by [illegible]
55[illegible]	47'	5'	"	25,782				
106	47'	[illegible]	"	[illegible]				
353	47	[illegible]	"	1,2[illegible]				
106	46'	[illegible]	"	34,122				
144	13'	[illegible]	"	9,828				
				1,95,500	58,000	1,37,500	"	From Hookes Banks do do
555'	10'	3'	"	16,650				
205'	5'	15.6"	"	15,887				
205'	9'	5'	"	9,225				
200'	20'	3'	"	12,000				
1012'	10'	16.3"	"	1,97,556				
1012'	10'	4.3"	"	52,116				
30'	15'	16'	"	7,200				
150'	55'	5.6"	"	46,500				
17'	55'	9.9"	"	8,937				
50	Area	135"	"	67,550	"	4,[illegible]	"	From 15th Mile [illegible]
90'	55'	[illegible]	"	15,795				
213'	50'	[illegible]	"	33,2[illegible]				
40'	10'	5'	"	2000				
230'	50'	1.9"	"	20,125				
1330'	50'	2'	"	133,000				
130'	10	16.6"	"	21,450				
120	10'	2'	"	2,400				
50	Area	740	"	37,000	1,01,600	79,5[illegible]	17,555	From 16th [illegible] do. do. do.
				2,85,220	86,500	"	"	Do. Do. by [illegible]
952'	34'	2'	"	17,136				
252'	14'	8'	"	28,224				
250'	22'	8'	"	44,000				
100	30	4.8"	"	20,625				
				1,09,985	54,500	55,485	"	From Hookes Banks do do.
543'	10	2.3	"	1,09,957				
543'	2'	3.4	"	3,702				
477	5'	[illegible]	"	50,085				
477	3	5'	"	7,155				
200	16	2'	"	6,400				
67'	11.9	[illegible]	"	11,261				
Carried over				2,90,560	10,48,203	26,67,[illegible]	3,27,612	

Embankment — Earthwork

Cubic contents	Channel	Banks	[illegible]	Spreading earth & carrying &c.	Puddling	Removing from channel	Miscellaneous	Dressing slopes	Remarks
290,560	1048203266,7333		327412	"	"	"	"		
60,000									
7,041									
10,710									
85,560									
700									
25,350		479,4[illegible]							From 15th Mile in hand wagons, 12000 ft.
9,975									
68,200									
41,077									
8,640									
72,000									
63,600									
28,800	22,600	29,074	33,693						From 16th do do do do do.
292,872	400								16. 200 [illegible], Govt. [illegible]
32,200	21,300	10,900							From Ren[illegible] Banks do do, 5800 do do.
45,000									
26,400									
6,600									
88,036									
500				"	"	60000			In Embankment
166,756				80,000	"	"			In Channel
65,000				"	"	26,766			In Banks.
7,875					"	47,875			To Embankment.
79,875				20,000	"	"			In Channel.
"				30,000					In Do.
14,600									
2,600									
33,340									
50,340				50340					In embankment.
"						16,500			In Banks.
"						8100			Do.
"						15,000			Do.
30,733									
91,600									
24,000					28,033				In channel
"					2295				Do.
6,750									
7,500		14,250							From 16th Mile in [illegible], [illegible] 150 ft.
"							14,250		and removed from [illegible] of Aqueduct.
6,550									
4,025									
5,880									
1,350							1,707		Preparatory to dressing Slopes.
"								22,600	
1,012									
11,132									
21,600									
480							34,324		For foundation of Piers and Embankment Repairs.
Total 1,296,903	32,01,463	363,505	185,340	290,828	174,231	48,281	22,800		Earthwork Do.

(Signed) C. A. Goodwyn [illegible]

Ex: Engr. [illegible] Ganges Canal [illegible]

[illegible] of the foregoing.

Description																			Remarks
	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	Cubic feet	
[illegible]	291,372	108,342	48,242	"	+156,303	124,668	226,215	"	10,000	1,022	"	"	66,356	"	"	"	"	"	* Of this quantity 118,715 feet are com-
[illegible] Tops	"	"	"	127,008	"	"	"	"	"	"	"	"	"	"	"	} 34,224	"	"	pleting finished, the
[illegible]	19,734	"	"		"	"	"	"	"	"	"	"	"	"	"		"	"	remainder is un-
[illegible]	"	"	"		"	3,009,646	397,300	202,112	"	1,945,251	"	135,000	"	290,598	14,950	*	"	"	polished
[illegible]	"	"	"		"	2,130,206	755,738	"	12,195	225,074	14,250	30,340	107,875	"	"	"	17,807	22,800	
Totals	511,106	108,342	48,242	127,008	156,303	1,758,620	1,281,173	202,112	22,995	485,421	14,250	185,340	174,231	[illegible]	16,230	34,224	17,007	22,800	

[illegible]

APPENDIX D

GENERAL INSTRUCTIONS

[redacted]

THE EXECUTIVE OFFICERS

OF THE

THIRD, FOURTH, FIFTH AND SIXTH DIVISIONS

[redacted]

Ganges Canal Works.

European establishment for supervision.

The establishment authorized for the executive supervision of each of the [redacted] divisions of works on the Ganges Canal [redacted] follows:—

1 Executive Officer and 2 Assistant Executives.

Overseers, as they may be required, for the supervision of work; but only one in the first instance.

Ultimate limit of establishment as sanctioned.

2. The Schedule given in the margin* shews the limit of the permanent establishment [redacted] sanctioned by Government, but it will be understood that [redacted] portion only will be required at present, and that [redacted] addition [redacted] the numbers and salaries specified in the following paragraphs will be made without the special sanction of the Director of the works.

* ENGLISH OFFICE.			
1 European Accountant,	..	100 0 0	
1 English Writer,	..	45 0 0	
1 Assistant ditto,	..	25 0 0	
			170 0 0
NATIVE [redacted].			
1 Moonshee,	..	30 0 0	
1 Assistant Moonshee,	..	15 0 0	
1 Native Surveyor,	..	25 0 0	
1 Native Doctor,	..	15 0 0	
2 Sowars at 15 Rs. each,	..	30 0 0	
1 Duffadar of Burkundauzes,	..	6 0 0	
4 Burkundauzes at 4 [redacted]. each,		16 0 0	
1 Chuprassy,	..	6 0 0	
2 Chuprassies at 5 [redacted]. each,	..	10 0 0	
4 Classies at 4 Rs. each,	..	16 0 0	
			169 0 0
TREASURY.			
1 Treasurer,	..	20 0 0	
1 Assistant Treasurer,	..	10 0 0	
1 Jemadar,	..	8 0 0	
1 Duffadar,	..	6 0 0	
16 Burkundauzes at [redacted] each,	..	64 0 0	
			[redacted] 0 0
WORKS.			
1 Mistry Smith,	..	25 0 0	
1 ditto Carpenter,	..	25 0 0	
1 ditto Bricklayer,	..	15 0 0	
1 Assistant Mistry Bricklayer,	..	12 0 0	
1 Jemadar of Chuprassies,	..	8 0 0	
10 Chuprassies at [redacted] Rs. each,	..	50 0 0	
			135 0 0
Total Company's Rupees...			[redacted] 0 0

[redacted] permission [redacted] employ, with detached parties on works under overseers,
1 Moosuddie at [redacted] Rupees,
1 Chuprassy at 5 Rupees,
And a Guard proportionate to the Stores [redacted] Treasure [redacted] charge.

English Office, as now required.

3. ENGLISH OFFICE.—An Accountant and one English Writer will suffice in the first instance. Their salaries must depend on the nature of their qualifications. To secure the services of known and efficient men the full salaries of 100 rupees and 45 rupees, respectively, may be given; but considering how small the expenditure and how simple the accounts will be for some time, I would prefer, in the first instance, that a young man be taken on trial as an Accountant on a salary of from 60 to 80 rupees per mensem.

Native office, as now required.

4. NATIVE OFFICE.—The undermentioned Native Office Establishment may be entertained at once.

1 Moonshee,.........	at	20 rupees per mensem.
2 Native Levellers,	at	15 or 20 rupees ditto.
(According to qualifications).		
1 Native Doctor,...	at	15 rupees per ditto.
2 Sowars, ...		15 rupees each, ditto.
1 Duffadar, ...		[illegible] rupees ditto.
4 Burkundauzes, ...		4 rupees ditto.
1 Chuprassy, ...		5 rupees ditto.
2 Chuprassies, ...		4 rupees ditto.
4 Classies,............		4 rupees ditto.

Treasury Office not now required.

5. THE TREASURY OFFICE and GUARD will not at first be required.

Establishment for Works.

6. WORKS.—The Executive Engineer may entertain at once, 1 Mistry Smith, 1 ditto Carpenter, 1 ditto Bricklayer, at salaries not exceeding 15 rupees, for employment in the workshops; at 12 rupees, to superintend the building of the workshops and pucca bench-marks.

Establishment with detached Assistants and Overseers.

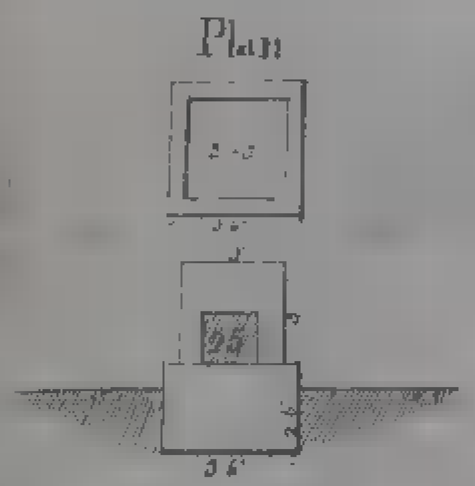
7. Each Assistant or Overseer, detached, to have a Mootsuddie at 10 rupees, a Chuprassy at 5 rupees, and a guard of 4 Burkundauzes, of whom one would receive 5 rupees, the others 4 rupees per mensem.

First business of the Executive Officer.

8. The first business of the Executive Officer will be to obtain by his own labor and that of his Assistants and native Levellers accurate information of the surface levels of the country throughout his division.

A longitudinal line of levels to be first carefully laid down.

9. He will first select two masonry bench-marks, respectively at the upper and lower extremities of his district, as near the probable line of Canal as possible, using for this purpose, some distinguishable existing object not liable



to displacement, or in the absence of such, he will build a masonry pillar of the form noted in the margin. The relative levels of these two points will be accurately ascertained by several trials, and the level of the upper one will be *provisionally* assumed as the zero, or starting point, for the general levels of the division.

These levels to be ultimately referred to that of the Myapoor regulating bridge.

10. In the foregoing paragraph I use the word "provisionally," because the levels of all the divisions must ultimately be referred to the sill of the Myapoor regulating bridge; and the Executive Engineer of the Munglour division, who has already referred his levels to the work above mentioned, as a zero point, will be instructed to fix the level of bench-marks at the south eastern extremity of his division on both sides of the *Kaleenuddee*, and to communicate these levels respectively to the Executive Officers of the Boolundshuhur and Futtehgurh divisions, who, having referred their levels to the same standard, will communicate the result to the next in succession: and so on.

Connected series of cross levels to be laid down.

11. In connection with the work above described, the Executive Engineer will take, or cause to be taken, a combined series of longitudinal and cross levels over the whole of his district. The proximity of these lines to each other will be regulated by the nature of the country, (whether undulating, flat, or having a uniform slope) but should be such as to mark clearly the principal water-shed lines, as well as all the lines of drainage.

Mode of exhibiting the result of the levels.

12. The results of this examination would be best exhibited on a map, drawn to a scale (say 4 inches to a mile,) that will admit of each level point being shewn, with its height (referred to the Myapoor zero) written in figures.

Specific object of the enquiry.

13. The object for which this information is required, and which' therefore, should be kept steadily in view while collecting it, is to facilitate the selection of the best possible line for the main and branch Canals as well as for the irrigation channels or *Rajbuhas* for distributing the water to the villages.

Principal considerations in selecting the lines of main Canal.

14. In selecting the line for the main Canal, the following points will be carefully considered:—

I. To keep the Canal as much as possible on the highest ridge, so as to facilitate the distribution of water for irrigation, and not to interfere with the drainage of the country.

II. To ensure a depth of cutting which will provide earth sufficient for the requisite embankments, and keep the Canal nearly, if not entirely, "within soil."

III. To keep the Canal as much as possible in straight lines, and when a curve is unavoidable, that it should be of not less than two miles radius.

Selection of lines for Rajbuhas.

15. In selecting lines for *Rajbuhas*, the first only of these considerations need be observed. The level of the water in these channels should be as a general rule slightly *above* that of the adjacent lands, and their general direction would of course be regulated by the position of the villages to be irrigated.

Fig. 2. P. 113

Bench-marks to be established at short intervals.

16. In carrying on the series of levels above described, it is very important that permanent bench-marks should be established at short intervals, and where wells, tombs or small religious buildings may not be met with in localities suitable for this purpose, it will be advisable to build small blocks of masonry of the size and form noted in the margin, and numbered. It is evident that the utility of bench-marks will depend in a great degree on the facility and certainty of their identification, the means of which must therefore be carefully provided by the surveying officer.

Existing buildings used as bench-marks to be accurately noted in the Field Book.

17. When an existing building may be used as a bench-mark, a sketch of the building should be made in the Field Book with such a degree of accuracy and detail as would enable another person to recognize the object without difficulty. The part of the building on which the levelling stave is placed should be that least exposed to injury, and should be carefully marked in the sketch.

Precautions against mistakes.

18. To obviate mistakes from indifferent drawing or the general similarity of wells, suttees, &c. the dimensions of one or two principal parts of the building should be accurately measured, and noted in the sketch. As an additional precaution, it would also be advisable to take compass-bearings from the bench-marks, to two or three conspicuous objects within sight.

Means to be used for the identification of the pillars.

19. Where pillars of masonry are built as bench-marks, the numbers (which will be cut in 3-inch figures on the plaster in a niche or recess of the pillar,)

would afford a sure means of identification; but lest these numbers should be defaced, it would also be expedient to fix the position of the bench-mark, by bearings to conspicuous objects, as above described. The levelling stave should be placed both on the top of the pillar and on the plinth, and the level of both these surfaces should be recorded, as a precaution in the event of one of them being injured.

Uses to be made of the bench-marks.

20. Bench-marks, fixed with the care and precautions above prescribed, will be exceedingly useful for future reference, and as a check on the native levellers, whose work will always begin and close upon these fixed points, and may be received with confidence, when it is found to agree with a standard with which the operators were not previously acquainted.

Enquiries regarding building materials, &c.

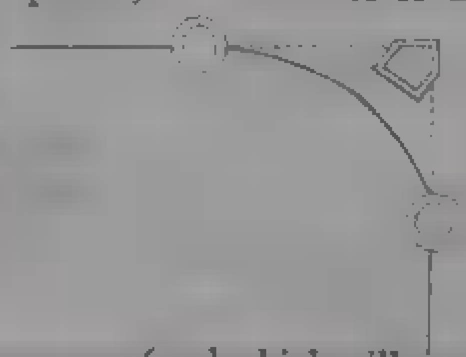
21. During the examination of the country, the attention of the Executive Officers, and assistants, should be directed to ascertain the localities and quality of building materials to be obtained in the district, such as kunkur, or marle, fit for the preparation of cements, block-kunkur suitable for building purposes, and brick, earth, &c. The value of different kinds of kunkur for cement, should be tested by experiment, and the result reported for the information of the Director.

Arrangements for bricks.

22. After the main line of Canal shall have been approximately fixed, arrangements may be entered into for the manufacture of bricks on that line, wherever fuel may be available; the quantity being regulated by a rough calculation of the requirements, according to the printed estimates, and with reference to the bridges, &c. required on *Rajbuhas*.

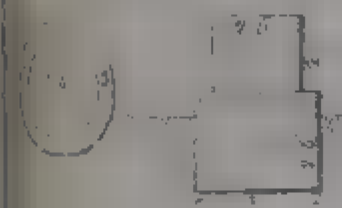
Main line to be carefully marked with masonry pillars.

23. When the direction of the main line has been definitely decided on, the central, or mesial line, should be laid down with the greatest care, and marked with small masonry pillars, at distances of not less than ½ of a mile apart, so as to be easily visible, one from the other, and in cases of change of direction, a pillar would be built at each of the tangential points, and a third at the intersection of the tangents.



Description of pillars.

24. The pillars built for the above purpose (and which will serve as points of reference for levels as well as for direction) will be circular in plan, and of dimensions as per margin. Those at the intersection of tangents will be of a different pattern; thus:



25. The sites of the bridges and other masonry works would then be determined in communication with the Director, by whom specific instructions would be issued, regarding the details of their construction.

Bridge sites to be determined upon;

26. It will generally be advisable to construct the 1st and 2nd class chokies, as soon as the line of Canal and sites of bridges, have been determined.

and chokees built.

27. The exact length and longitudinal section of the main and branch lines of Canal being determined, the quantity of earth-work will be calculated, and an estimate will be framed and submitted to the Director, of the time probably required to complete the excavation, with reference to the resources of the country and facility of procuring contractors. The Director will then communicate his orders, regarding the period for commencing the work.

Estimate of earth work to be prepared.

28. In the Schedule of Establishment, in paragraphs 1 and 2, are included one European Overseer, a Blacksmith, and a Carpenter Mistry. The object of the early entertainment of these men, is the establishment of a workshop, at or near the place, where the Executive Officer may fix his head-quarters. The Blacksmith's department would be employed in the manufacture of tools, such as mamooties, (fourahs) pickaxes, felling axes, &c., and the Carpenters in the preparation of brick-moulds, soorkhi mallets, cubic measures for lime and soorkhi, 10 feet and 5 feet rods, wheelbarrows, &c.

Workshops to be established, and how employed.

29. The building for the workshops may be on the same general plan as that sanctioned for the Munglour division, of which I enclose a ground plan and elevation (Appendix A.) and for which an estimate must be submitted.

Nature of building for the workshops.

30. The Executive Officer will be provided, in the first instance, with one large levelling instrument, and as many smaller ones, up to six, as can be obtained, previous to the arrival of those commissioned from Europe. He will also be supplied with a theodolite, if such can be obtained from the magazines; otherwise, he will have to wait for those ordered from home. Some pairs of levelling rods (probably as many as may be required) will be forwarded from the Director's Office.

Levelling and surveying instruments how to be provided.

31. For iron measuring chains, and as many mamooties, felling axes, &c. as are likely to be required in carrying on the levelling operations, indents on the nearest magazine will be prepared by the Executive Officer, and transmitted through the Director's Office, for sanction.

Certain indents to be submitted.

32. Bills for establishment salaries will be submitted monthly in the usual form, the general authority being quoted in the heading, and the special authority for any change or increase of salary being separately stated. The usual form of attestation will be appended to the bill, which must also be accompanied by acquittance rolls, in English and Persian, signed or sealed by each of the establishment in the receipt of a salary amounting to 10 rupees a month or upwards. The names as well as the designations of all the establishment receiving 10 rupees a month or upwards, must also be entered in the body of the bill.

Bills for salaries of establishment how prepared.

33. All expenditure on works will be charged and submitted quarterly, agreeably to the appended copy of "Rules" (Appendix B.) promulgated by Government, North Western Provinces, and communicated to me in Mr. Secretary Thornton's letter No. 500 A. of the 25th August, 1847.

Expenditure on works to be charged quarterly.

34. The first bills will consist of little more than the contingent expenses of surveying, but when there may be occasion to charge for work admitting of measurement, the bill will be prepared in the usual departmental form, and will consist of a statement of expenditure on labor and materials (separately) for each work, an exhibition of the rates at which each description of work was actually executed, and a comparison of the actual and estimated rates.

Form of the quarterly bills.

35. To each bill will be appended a statement of measurements of the work charged for, and a survey report in the usual form.

Measurement of work and survey report.

36. The whole quarterly expenditure, though included in one bill, will be shown in separate items specifying the several descriptions of work on which it was incurred. The precise detail of this sub-division, for each principal work, will be prescribed by the Director.

Detail of the quarterly bills.

37. In preparing the comparison of actual and estimated rates, the Executive Officer will bear in mind, that it is the object of Government, that the rates exhibited should be those of the *actual* cost of each description of work. The heading of this part of the bill will be worded accordingly, and the attestation, on honor, will be held to apply to the rates as well as the amounts charged.

The rates to be deduced bona fide.

38. The "comparison of rates" will be followed by an "explanation of differences," in all cases where there may be a discrepancy, one way or the other, between the estimated and actual rates.

Explanation of differences.

39. The expenditure on materials will be brought forward in the manner described in clause IV. and in paragraphs 5, 6 and 7, of clause III. of the annexed "Rules."

Expenditure on materials.

40. The accounts of expenditure kept by the Executive Officer and required by him from his subordinates, must be closed monthly, and will be prepared with special reference to the system of accounts embodied in the Agra Government "Rules."

Accounts to be kept by the Executive Officer.

41. The forms prescribed by the Military Board for the accounts of the Department of Public Works, are appended to this communication (Appendix C.) but a modification of this system has been generally adopted in the Canal Department.

Forms of accounts prescribed by the Military Board.

42. The "Day Book," as prescribed, is intended to be sent in daily to the Executive Officer, and this would be attended with much advantage, where extensive works are being carried on at one spot under the immediate supervision of the Executive Officer. As, however, it generally happens in the Canal Department, that the expenditure is incurred by assistants or overseers at different localities, and not under the immediate supervision of the Executive Officer, whose duty it is to control the whole, it has been found convenient in practice to combine all the information contained in the "Day Book" in a monthly statement, the form of which is appended (see Appendix D).

Modification of these forms adopted in the Canal Department.

43. The only real difference between this method and that of the Department of Public Works, is that the expenditure is reported, in the one case daily, in the other monthly, to the Executive Officer; the degree of detail in both plans may be the same.

Difference between the two methods.

44. The precise form in which the daily expenditure shall be reported to the Executive Officer, is left in some measure to his own discretion, under the proviso that the accounts of all his subordinates shall be susceptible of easy check, and that they, as well as the books prepared from them in the Executive Engineer's Office, shall contain all the details of information expected or required by the Military Board or by Government.

The accounts to contain all the information required.

45. A list of periodical papers, to be transmitted to the Director's Office, is subjoined. (See Appendix E.)

List of periodical papers.

46. Whenever it may be necessary to take up ground for Canal purposes, or to cut down trees, or remove wells or buildings, interfering with the line of Canal, the

Claims for compensation.

proprietors of such land, trees or buildings, will be entitled to compensation, which will be awarded in strict accordance with the rules laid down in Mr. Secretary Thornton's letter to the Sudder Board of Revenue, No. 360, of 27th January, 1845, a copy of which forms Appendix F.

Assistance from the Civil authorities of districts.

47. In accordance with the instructions of his Honor the Lieutenant-Governor, North Western Provinces, communicated to the Sudder Board of Revenue, N. W. P., under date the 25th August, 1847, the Revenue Officers of the districts through which the Ganges Canal will pass, have been apprised of the approaching commencement of the work, and have been directed to afford every necessary assistance to the Officers of the Canal in their progress through the country. It must be understood, however, that the Executive Engineers are not to rely upon the assistance of the Civil Officers, to procure labor or carriage for the works. These will be generally obtainable by good management, and by a system of regular payment and considerate treatment of the parties employed.

Due respect to be paid to Native Revenue and Police Officers.

48. The Executive Engineers will impress upon all their subordinates the necessity of treating with the consideration due to their official functions, the Native Officers of the Revenue and Police departments, with whom they may be brought in contact, in the discharge of their public duties.

Contract work recommended.

49. In the execution of work, it is advisable to adopt a system of contracts, whenever such can be obtained on reasonable terms. The works most easily susceptible of contract, are, the excavation of a cut or formation of an embankment, of a given section; manufacture and carriage of bricks, lime and *soorkhi*; quarrying and carrying blocks of *kunkur*, &c.

Remarks upon hired labor.

50. When hired labor is employed, that supplied by the neighbouring villages, and paid daily, is generally the most economical; but when larger parties are required than the neighbourhood can supply, or when any particular work is in progress, (such as block-sinking) which requires practised workmen, it then becomes necessary to employ laborers (*bildars*) on monthly pay, and to enforce strictly a system of task-work.

Organization and description of *bildars*.

51. The *bildars* should be divided into *mudduts*, or squads of 30 to 40 men each, under charge of a tindal, who will receive [illegible] rupees per mensem, and who will be generally held responsible for the conduct of

his men, and may be punished for their remissness, at the same time that his authority is strictly upheld.

Collective preferable to individual tasks.

52. It will be generally found advisable to assign collective rather than individual tasks, *i. e.*, to measure out a certain portion of work to a whole squad, and not to each *bildar*. On this plan, each man has a direct interest in seeing that the others work, and in preventing truancy and skulking.

Terms on which absence on the plea of sickness can be granted.

53. When large parties of monthly paid laborers are employed, it is important that the terms on which absence on the plea of sickness can be allowed, should be well understood. The method in use in the northern division of the Ganges Canal, is recommended for general adoption. It is as follows:

Hospital accommodation is provided for the work people in the event of sickness. Men, who have been injured on the works, receive full pay during their hospital treatment. The other hospital patients receive half-pay. Men who absent themselves from work under the plea of sickness, but do not go into hospital, receive no pay while non-effective.

Indents for stationery.

54. The Executive Engineers of the Ganges Canal are supplied with stationery from the Government stores, on which an indent, prepared agreeably to the accompanying form, (see Appendix G.) should be submitted through the Director's office, as soon as possible after the 1st July of each year.

Decisions on references on different subjects.

55. To prevent the necessity of future references, I subjoin (Appendix H.) a list of questions which have been referred from time to time by Executive Officers, and the authoritative decisions thereon, in parallel columns.

W. E. BAKER, Major,
Director, Ganges Canal Works.

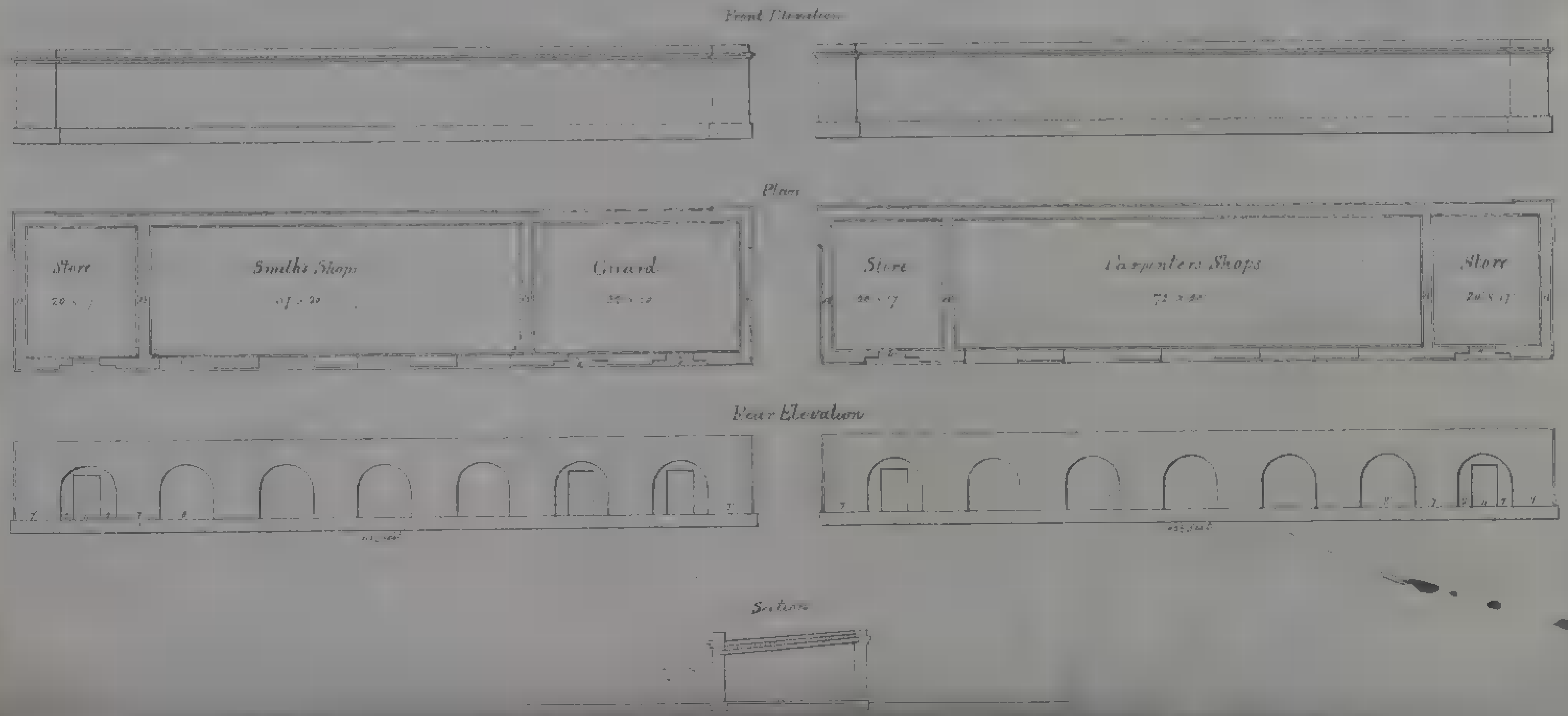
Roorkee,
September 30th, 1847.

APPENDIX A.

GENERAL PLAN OF WORKSHOPS

on the

GANGES CANAL



APPENDIX B.

RULES FOR KEEPING THE ACCOUNTS ON THE GRAND GANGES CANAL.

I. The works shall be executed agreeably to Major Cautley's designs. No deviation from the principles which have been sanctioned by Government to be made without the previous approval of the Military Board. The Director will be competent to authorize such modifications as may be necessary to the efficiency of the work in progress, reporting the same immediately to the Military Board.

II. When money is required for the execution of works, application will be made by the Executive Engineer, through the Director, to the Accountant, North Western Provinces, who will issue an assignment for the amount.

III. For the Northern Division.

The Executive Engineer of *Works* will submit to the Director a bill for three (3) months' work prepared in the usual departmental form, i. e. exhibiting quantities, rates and amounts, and accompanied by detailed measurements of work done.

2. The materials used to be charged for on rates furnished by the Executive Officer of *Materials*.

3. When the rates of work differ from the estimated rates, full explanations to be given at the foot of bills in the usual manner.

4. The bills after careful examination by the Director will be submitted with his remarks to the Military Board.

5. The Executive Officer, whose duty will be to collect and prepare materials and to take charge of bullocks, carts, &c., will submit quarterly to the Director for transmission to the Military Board, a detailed statement of expenditure and results in each item of his charge including carts and bullocks, accompanied by such explanations as may appear to be necessary.

6. To the above Statement will be appended a balance sheet, shewing on one side the actual expenditure on each item, and on the other the amounts received from the Executive Engineer of Works, and the stock in hand.

7. He will also submit a list deduced from the above mentioned accounts of prices of materials, bullock hire &c., which he proposes to charge during the ensuing quarter, to the Executive Engineer, to whom it will be communicated by the Director, if approved.

3. The Executive Officer for Materials will get advances from the Executive Engineer of Works and will write off per contra, the value of materials supplied.

IV. In the smaller divisions it may be expedient from motives of economy to unite [redacted] Officer the functions of the two allowed to the 1st Division.

2. The Executive Engineer of a smaller division will therefore keep and submit quarterly to the Director, distinct accounts of works and materials [redacted] laid down tor the *two* Officers of the 1st division.

V. On completion of any work extending through more than [redacted] quarter, the Director will draw out and submit to the Military Board a comparison of its actual cost with that estimated, at the same [redacted] reporting [redacted] the quality of work, &c. &c. Every work commenced and completed within the quarter, will, by the Director, be separately reported on, [redacted] to its quality, &c.

VI. General accounts, of expenditure on the Canal works of all descriptions, will be kept [redacted] the Director's Office, and balance sheets will be submitted to Government, quarterly or half yearly, [redacted] may be required.

J. THORNTON,

Secy. to Govt. N. W. Provinces.

APPENDIX C.

Forms to be observed by Barrack Masters *in keeping Accounts; approved and adopted by the* Military Board, *on the 1st May*, 1821.

As a uniform system of accounts should be adhered to throughout the Barrack Department, the following forms are selected as the most convenient, with reference to the documents required to accompany bills for work executed.

Each district Barrack Master must keep five Books, viz. No. 1, a Journal or Day Book, No. 2, an Abstract of Daily Cash Payments, No. 3, an Abstract of the Daily Expenditure of Materials and Labor, No. 4, a Stock Book, and No. 5, a Book for Advances in the shape of an Account Current.

In Book No. 1, all the disbursements of every description must be inserted each day, under its proper head; when a payment is made for general purposes, and not for any particular building, it must be entered under that head.

Book No. 2 is intended for easy reference. The horizontal columns shew at one glance of the eye the amount expended each day on the several works, as well as the total expense of the day. The vertical columns, when added up, shew at once the total sum expended on any work up to any fixed date, as well as the total expenditure. This book, by being kept up regularly, will be found to save much time.

Book No. 3 is intended to record the labor and materials expended each day on different parts of the same buildings. For this purpose several pages or half pages must be allotted to one building, viz. half a page for the foundations, one or more pages for the superstructure, roof, floor, cornice, &c., &c. It affords the means of adding up separately and readily the expenditure on each part of a building, and when this book is accurately kept, nothing is more simple than the making out the bill, at the completion of the work. All that is required, is, to take the total of each description of work, and the bill is ready. No. 4 is to shew readily what materials have been purchased, the average cost of them, and their appropriation. No. 5 is the same description of book, but has reference to individuals, instead of materials; it is a personal account current with each Contractor, Merchant, Agent, or Head Mechanic, shewing what advances have been made and what has been received for the money, and what is due. Each account with a native must be balanced monthly, and the man's

signature affixed, or his acknowledgment of its being correct tacked to it. With Europeans it may be sufficient to balance the account quarterly. The book No. 3 cannot be kept accurately, unless a sufficient number of Lallahs [redacted] Mohurrurs [redacted] kept at the works, to see what labor and materials are used, and to send to the office [redacted] daily Report in writing which should be filed as soon as it has been entered in the books.

Experience has shewn that the first expense of keeping up [redacted] sufficient number of writers is amply compensated by the advantages of an early adjustment of accounts, and it will be readily [redacted] that it is much easier to write [redacted] few lines in the books daily, than to have intricate accounts to make out when any work [redacted] finished; and in the event of any sudden removal or any accident occurring to [redacted] Barrack Master, his successor will easily continue the accounts and adjust all claims. A set of books of the prescribed form must be kept at each post, or station, and when this cannot be done [redacted] the English language, it must be done in Persian or Bengalee.

When money is sent to [redacted] native Agent [redacted] Overseer to carry on works at [redacted] outpost he must be ordered to send regular monthly accounts, and [redacted] shew by the attestation of the parties concerned, that all advances [redacted] account, have been regularly balanced and adjusted for the past month. Receipts in duplicate for all advances must be regularly executed.

No. 1.

Form of Day Book.

1816 February			Rs.	A.	P.	Rs.	A.	P.
		STABLE No. 2 LINE.						
	1	1 Mate Mason, ...	0	4	0			
		44 Masons @ 2½ annas each, ...	6	14	0			
		27 Bildars @ 3¾ pice each...	2	15	8			
		105 Coolies 1st @ 2½ annas each, ...	7	11	6			
		35 Ditto 2nd @ 1 anna each, ...	2	3	0			
		19 Boys @ 2 pice each, ...	1	2	11			
		1 [illegible] Bheestie, ...	0	2	6			
		15 Bheesties @ [illegible] annas each, ...	1	14	0			
		10 Bundaries, ...	1	4	0			
		1 Mate and 8½ Carpenters @ 2¼ as. each,	1	8	3			
		6 Sawyers, ...	0	15	0			
		16 Chakees, ...	4	15	4			
						31	13	2
		STABLE No. 4 LINE.						
		1 Mate Mason, ...	0	3	0			
		12 Masons @ 2½ annas each, ...	1	14	0			
		15 Bildars @ 3¾ pice each, ...	1	10	6			
		27 Coolees 1st @ 2½ each, ...	1	15	9			
		7 Ditto, ...	0	0	0	5	11	3
		Total expended 1st February, as per figured Cash Abstract, ...				37	8	5
		ADVANCES FOR GENERAL USE OF THE DEPARTMENT.						
	2	To Shack Ramjaun, for lime, ...	300	0	0			
		,, Googee Churn, Mistry, for bricks, ...	200	0	0			
		,, Jugun Churn, ditto for firewood, ...	50	0	0			
		,, Ramgeeon, for Soorkhie, ...	20	0	0			
						570	0	0
		WORKMEN.						
		Quarter Master Sergeant's House, Infantry Lines.						
		1 Mate Mason, ...	0	4	0			
		50 Masons @ 2½ annas each, ...	9	8	0			
						9	12	0
		HOSPITAL [illegible] 2ND BATTALION 9TH.						
		1 Mate Mason, ...	0	4	0			
		61 Masons @ 2½ [illegible] each, ...	9	8	6			
						9	12	6
		CANTONMENT ROAD.						
		[illegible] Bildars, ...	0	14	0			
		2 Ditto boys, ...	0	3	0	1	1	0
		Total Expended 2nd February, ditto				590	9	6
	3	Advanced to John Ullee, Native Agent at Mullye, ...	100	0	0			
		Ditto to Lallah Gunga Ram, [illegible] Kishen Gunj, ...	50	0	0			
		Ditto to Goolmahomed ditto Chuppra,	500	0	0			
						650	0	0

No. 2.

Form of Cash Abstract of Daily Cash Payments.

Date.	Stable No. 2.	Stable No. 4.	Quarter Master Sergeant's house Infantry lines.	Hospital 2nd Battalion 9th Regiment.	Cantonment Road.	Advances for general use of the department.	Kunkur.	Lime kiln.	Magazine.								Total disbursements each day. For particulars—See Day Book.
1816, Feby. 1st	31 13 2	5 11 3	— 0	0	0	0	0 0	0	0								37 8 5
2nd	0	0	9 12 0	9 12 6	1 1 0	570	0	0	0								590 9 6
3rd	0	0	0	0	0	650		0	0								650 0 0

No. 3.

Figured Abstract of Daily Cash Expenditure of Labor and Materials.

No. of feet.	Description of building.	Head Masons.	Masons.	Bildars.	Coolies, 1st.	Coolies, 2nd.	Boys.	Bheesties.	Carpenters.	Sawyers.	Grammies.	Bricks.	Lime.	Sand.	Soorkhi.		Total Expense.		
C. feet.													*mds.*	*mds.*	*seers.*				
192 9	Foundation wall, 19th December, 1815, ..	1	3	5	4	1	3	1	0	0	0	1000	2	3	20				
		4	5	10	6	1	1·6	2	0	0	0	5	1-8	1-8	3		10	0	6
257 3	Do. do. 20th do. ditto. ...	1	3	4	4	1	3	1	0	0	0	500	1	1½	20				
		4	7·6	8	6	1	1.6	2	0	0	0	2-8	12	12	3		6	1	0
480	Total cubic feet in foundation, ...																16	1	6
200	Superstructure, 21st December, ...	0	0																
210	Do., 22nd ditto, ...	0	0																
		0	0																
210	Do., 23rd ditto, ...	0	0																
620	Total cubic feet in superstructure, ...																		
300	Plaster wall, 23rd December, ...																		
250	Roof Do., 23rd December, ...																		
230	Cornice Do., 23rd December, ...																		
230	Total running feet of cornice, ...																		

No. 4.

Form of Stock Book.

1815, January,	0,000 Bricks, received from Ramjaun, Brick Contractor, at 00 per 0000, ...	0 0 0	1815, February,	0,000 Bricks issued for the Quarter Guard of the 9th Regiment Native Infantry, at 00 per 000,	0 0 0
			March,	1 Balance in store, ...	0 0 0
March,	0,000 Maunds of Lime, received from Mr. A. B., at 00 per 100 maunds, ...	0 0 0	May,	0,000 Maunds Lime issued for white washing Artillery Barracks, at per 100 maunds, . .	0 0 0
			May,	0,000 Maunds Lime despatched to Captain A. B., for commercial Buildings at Malda, at per 100 maunds, ...	0 0 0
			June,	1 Balance in store, ...	
March,	0,000 Ferrahs of Kooah received from C. D., Contractor, at per 100 Ferrahs, ...	0 0 0	April,	0,000 Ferrahs of Kooah issued for the Cantonment road at per 100 Ferrahs, ...	0 0 0
				Balance in store, ...	0 0 0
April,	0,000 Saul Timbers, received, &c., &c., ...	0 0 0	June,	0,000 Saul Timbers issued, &c., ...	0 0 0
				Balance in store, ...	0 0 0

No. 5.

Form of a Book for Advances in the shape of an Account Current.

		Mr. A. B., Lime Contractor. Dr.				Mr. A. B., Lime Contractor. Cr.	
1819, June,	0	To amount advanced to you in cash as per Receipt, ...	0 0 0	1819, June,	0	By 000 Maunds of Lime delivered at per 000 maunds, ...	0 0 0
July,	0	" Ditto, Ditto, ..	0 0 0	July,	0	By 000 maunds of Lime to Malda, Ditto,	0 0 0
August,	0	" Ditto, Ditto, ..	0 0 0	August,	0	By 000 maunds of Lime to Malda Ditto,	0 0 0
			0 0 0				0 0 0
						By Balance due to Barrack Department, ..	0 0 0
			0 0 0				0 0 0
		Ramtonoo, Brick Contractor. Dr.				Ramtonoo, Brick Contractor. Cr.	
June,	2	To amount advanced to you in Cash as per Receipt, ...	0 0 0	June,	9	By 000, 11 inch Bricks delivered at ..	0 0 0
				"	23	By 000, 12 inch Bricks ditto ..	0 0 0
				"	30	By 000, 11 inch Bricks ditto ..	0 0 0
							0 0 0
				July,	1	By Balance due to Barrack Department, ..	0 0 0
		(Signed) C. D., *Brick Contractor.*				(Signed) A. B., *Barrack Master.*	

APPENDIX D.

Sig. R. P 121
Vol. III

GANGES CANAL WORKS ———— DIVISION.

Daily Account of Work People employed and materials used, on the undermentioned works, during the month ——— of 1847.

No. 1.—Regulating Bridge.

Day	Masons at 8. R. A.	„ 7·8.	„ 7.	„ 4.	„ 3.	„ 3.	„ 2.	„ 1.	Mates at	„ 6.	Bildars at 4.	Chasies at 4.
1	10	3	5	15	1	1	6	2	0	2	70	1
2	12	22	6	1	1	1	6	2	1	6	221	1
3	16	22	7	0	1	1	6	2	1	3	113	1
4	9	12	3	0	1	1	6	2	1	3	102	1
5	18	19	1	0	0	0	0	0	1	4	157	1
6	20	17	3	0	1	5	1	0	1	4	157	1
7	32	16	4	0	1	1	0	0	1	5	193	1
8	11	17	3	0	0	0	0	0	1	5	229	1
9	14	14	4	0	0	0	0	0	1	5	198	1
10	12	17	3	0	0	0	0	0	1	5	184	1
11	12	18	3	0	0	0	0	0	1	9	320	1
12	15	17	3	0	0	0	0	0	1	9	328	1
13	17	17	1	0	0	1	0	0	1	9	327	1
14	19	16	5	0	0	0	0	[illegible]	1	9	330	1
15	13	15	4	0	0	0	0	1	1	4	161	1
16	1	3	1	0	0	5	0	0	0	2	76	1
17	3	1	1	0	0	0	0	0	1	3	113	0
18	5	5	0	0	0	0	0	0	1	5	112	0
19	5	1	1	0	0	0	0	0	1	4	55	0
20	8	2	0	0	0	0	0	0	1	4	55	0
21	3	6	1	0	0	0	0	0	1	0	31	0
22	1	5	0	0	0	0	0	0	0	0	0	0
23	4	3	0	0	0	0	0	0	0	0	12	0
24	4	4	1	0	0	0	0	0	0	0	31	0
25	5	4	1	0	0	0	0	1	0	0	31	0
26	5	1	0	0	0	0	0	0	0	0	12	0
27	1	0	0	0	0	0	0	0	0	0	12	0
28	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
	240	314	70	2	[illegible]	[illegible]	21	[illegible]	19	87	3650	16

No. 1.—Regulating Bridge (continued).

Day	Lime.	Soorkhi.	Sand.	2½ Bricks.	Oil.	Earthen vessels.	Baskets.	Gubrees.
1	0	0	0		0 61	26	35	4
2	210	210	210		0 0	17	199	4
3	0	0	0		0 0	0	4	4
4	0	0	0		0 0	7	0	4
5	0	0	0		0 0	6	0	4
6	0	0	0		0 0	0	0	1
7	130	130	130		0 0	0	0	2
8	236	236	236		0 0	0	18	2
9	0	0	0		0 0	0	18	2
10	0	0	0		0 0	0	0	2
11	0	0	0		0 0	0	197	2
12	0	0	0		0 0	0	0	2
13	0	0	0		0 0	0	0	2
14	0	0	0		0 0	0	236	2
15	0	0	0		0 0	1	0	2
16	0	0	0	66308	0 0	8	30	2
17	0	0	0		0 0	5	0	2
18	0	0	0		0 0	6	0	2
19	0	0	0		0 0	4	0	2
20	0	0	0		0 0	0	0	2
21	0	0	0		0 0	0	0	2
22	0	0	0		0 0	0	0	2
23	0	0	0		0 0	0	0	0
24	40	40	40		0 0	0	0	[illegible]
25	30	30	30		0 0	0	0	0
26	0	0	0		0 0	0	0	[illegible]
27	0	0	0		0 0	0	0	[illegible]
28	0	0	0		0 0	0	0	0
29	0	0	0		0 0	0	0	0
30	0	0	0		0 0	[illegible]	0	[illegible]
	676	676	676	66308	61·71	[illegible]	717	36

No. 2.—Excavation in the Canal for Railway.

Day	Mates at 8.	„ 7.	„ 5.	Bildars at 4.	Baskets.
1	0	3	2	212	10
2	0	3	2	213	10
3	0	3	2	218	0
4	0	3	2	220	0
5	0	3	1	229	0
6	0	3	1	127	0
7	0	3	2	127	40
8	0	3	2	124	0
9	1	3	3	173	95
10	1	3	3	169	0
11	0	3	1	96	0
12	0	3	1	95	0
13	0	2	1	59	0
14	0	2	1	69	0
15	0	2	1	66	0
16	0	2	1	65	0
17	0	2	1	60	0
18	0	2	1	60	0
19	0	2	1	60	0
20	0	1	1	27	0
21	0	1	1	27	0
22	0	1	1	27	0
23	0	0	1	0	0
24	0	0	0	0	1
25	0	1	0	0	1
26	0	1	1	0	0
27	0	1	1	0	0
28	0	1	0	0	0
29	0	1	0	0	0
30	0	1	0	0	0
	2	52	30	2521	275

No. 3.—Excavation for Channel of the earthen aqueduct.

Day	Mates at 8.	„ 7.	„ 6.	Mistree 5.	Chasies 4.	Bildars 4.	Baskets.
1	0	5	10	0	1	423	0
2	0	5	10	0	1	455	100
3	0	5	10	0	1	465	0
4	0	5	10	0	1	[illegible]	0
5	0	5	10	0	1	[illegible]	100
6	0	4	10	0	1	[illegible]	0
7	0	4	9	0	1	580	0
8	0	4	9	0	1	695	175
9	0	4	9	0	1	611	0
10	0	4	9	0	1	595	0
11	1	4	11	0	1	561	0
12	1	4	11	1	1	554	0
13	1	5	11	1	1	605	145
14	0	5	11	1	1	560	0
15	1	5	11	1	1	609	0
16	1	5	11	1	1	576	0
17	1	4	8	1	1	479	0
18	0	4	10	1	1	330	0
19	0	4	9	1	1	[illegible]	10
20	1	4	6	1	1	450	158
21	1	4	6	1	1	305	0
22	0	3	6	1	1	250	120
23	0	4	6	1	1	268	0
24	0	2	2	1	1	114	0
25	0	2	1	1	1	81	119
26	0	2	1	1	1	81	0
27	1	3	1	1	1	257	0
28	1	3	2	1	1	425	6
29	0	4	3	1	1	295	0
30	1	4	2	1	1	257	0
	11	120	225	19	30	12758	897

No. 4.—Bricks.

Day	Mates at 7.	„ 6.	Bildars at 4.	Baskets.
1	1	1	59	6
2	1	1	60	6
3	1	0	0	0
4	0	1	6	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	1	0	0
10	0	0	0	0
11	1	0	40	0
12	1	0	41	0
13	1	0	41	0
14	1	0	37	0
15	1	0	41	0
16	1	0	41	0
17	1	0	39	20
18	1	0	41	0
19	1	0	41	10
20	1	0	[illegible]	6
21	1	0	41	0
22	1	1	74	39
23	1	0	39	0
24	0	0	15	0
25	0	0	12	0
26	0	0	11	0
27	0	0	11	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
	15	3	731	65

No. 5.—Bridge centerings.

Day	Carpenters at 10.	„ 8.	„ 7·8.	„ 7.	„ 6.	Mates at 5.	Bildars at 4.	Rope.
1	1	7	3	6	2	1	33	0
2	1	2	3	3	1	1	25	1
3	1	4	5	4	0	1	37	0
4	0	2	1	2	0	1	37	0
5	0	1	2	2	0	1	38	0
6	0	2	2	2	0	1	38	0
7	1	4	2	0	0	1	38	0
8	0	0	0	0	0	1	38	0
9	0	0	0	0	0	1	38	0
10	0	0	1	0	0	1	37	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	0	1	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0
	4	23	15	16	2	10	349	1

No. 6.—Excavation for embankment.

Day	Mates at 8.	„ 7.	„ 6.	Bildars at 4.
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	2	2	107
18	1	1	1	211
19	1	1	2	244
20	0	2	4	162
21	0	2	4	440
22	1	3	1	455
23	1	3	4	498
24	1	5	8	551
25	1	5	9	554
26	1	5	9	554
27	0	4	9	357
28	0	4	5	225
29	1	3	7	368
30	0	3	8	392
	8	13	79	5151

GANGES CANAL WORKS —— DIVISION.

Abstract of Workmen employed and materials used on the undermentioned works during the month of —— 1847.

No.	Description.	Masons at 8.	" 7-8.	" 7.	" 4.	" 3-8.	" 3.	" 2.	" 1.	Mistrees at 9.	Mates at 8.	" 7.	" 6.	Classies at 4.	Bildars at 4.	Carpenters at 10.	" 8.	" 7-8.	" 7.	" 6.	MATERIALS. 2¼ Inch bricks.	Lime.	Soorkhi.	Sand.	Rope. (sr.)	Oil. (sr.)	Earthen vessels.	Bullocks.	Baskets.
1	Regulating Bridge, ...	280	310	70	2	4	4	24	8	0	0	19	87	16	3,650	0	0	0	0	0	66,308	676	676	676	0	6	74	56	747
2	Excavation in Canal for Railway, ...	0	0	0	0	0	0	0	0	0	2	52	30	0	2,521	0	0	0	0	0	0	0	0	0	0	0	0	0	275
3	Do. for channel of earthen aqueduct, ...	0	0	0	0	0	0	0	0	19	11	120	225	30	12,758	0	0	0	0	0	0	0	0	0	0	0	0	0	897
4	Brick kilns, ...	0	0	0	0	0	0	0	0	0	0	15	3	0	731	0	0	0	0	0	0	0	0	0	0	0	0	0	69
5	Bridge centres, ...	0	0	0	0	0	0	0	0	0	0	0	10	0	349	4	23	18	16	2	0	0	0	0	1	0	0	0	0
6	Excavation for embankment,	0	0	0	0	0	0	0	0	0	8	43	79	0	5,151	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total, ..	280	310	70	2	4	4	24	8	19	21	249	434	46	25,160	4	23	18	16	2	66,308	676	676	676	1	6¼	74	56	1,988

APPENDIX E.

List of Periodical Papers.

Monthly.

Statement of correspondence.
List of letters despatched by Executive Engineer.
Estimate of Funds required by Executive Engineer for the current and five ensuing months.
Report on disposal of Assistants.
Progress Report.
Current Expense Bill.
Statement of Assignments received and realized during month.

Quarterly.

Return of Warrant and Non-commissioned Officers' Bill for expenditure on Works, with Abstracts of quantity completed, &c.

Half Yearly.

General Sayer Account, to Accountant N. W. P., and Director.

Yearly.

Indent for Stationery.
Return of Magazine Tools.
Return of Levelling and Surveying Instruments.
Descriptive Roll and confidential Report of Overseers.
Return of Uncovenanted Servants.

GANGES CANAL WORKS ——— DIVISION.

Progress Report [illegible] *the undermentioned Works during the Month of* ——— 1847.

No. 1.—Regulating Bridge.

Part of Work.	Description.		L Feet.	L Inches.	B Feet.	B Inches.	D Feet.	D Inches.	Number.	Contents. c.ft.	in.	
Pillars, ..	Brick Work Masonry mortar,	1 Lime, 1 Soorki, 1 Sand,	5	6	5	6	2	9	4	332	9	0
ditto, ..	ditto,	”	5	0	5	0	1	3	4	125	0	[illegible]
ditto, ..	ditto,	”	5	6	5	6	0	9	4	[illegible]	9	0
ditto, ..	ditto,	”	5	0	5	0	0	6¾	4	56	3	0
ditto, ..	ditto,	”	9	6½	4	1½	2	9	2	216	5	7
ditto, ..	ditto,	”	9	0½	3	7½	1	3	2	81	11	3
ditto, ..	ditto,	”	3	7½	3	7½	1	3¾	2	34	5	10
ditto, ..	ditto,	”	4	2½	4	7½	1	3¾	2	51	0	10
ditto, ..	ditto,	”	7	1½	0	3	0	9	2	2	8	0
ditto, ..	ditto,	”	9	7½	1	0	1	9	2	33	8	0
Pier, ..	ditto,	”	6	4½	3	1½	1	7	2	63	0	10
Pillar Walls,	ditto,	”	6	7½	2	4½	7	9	2	206	11	10
ditto, ..	ditto,	”	7	8	0	3	1	0	2	3	10	0
Cutstone, cornice,	ditto,	”	10	0	1	0	1	5	2	28	[illegible]	0
Pillar Walls, ..	ditto,	”	2	3	2	3	9	4	2	94	6	0
Parapet, ..	ditto,	”	10	9	2	6	2	0	2	107	6	[illegible]
ditto, ..	ditto,	”	7	0	2	0	3	9	2	105	0	0
ditto Cornice, ..	ditto,	”	4	3	2	3	1	0	2	19	1	6
ditto, ..	ditto,	”	2	0	1	9	1	3	2	8	9	[illegible]
Wing Wall Cornice, ..	ditto,	”	29	3	3	0	1	9	4	614	3	0
ditto, and bench	ditto,	”	29	3	5	6	1	0	4	321	9	0
ditto, ..	ditto,	”	29	9	1	6	1	3	4	223	1	4
ditto, ..	ditto,	”	29	3	2	0	0	10½	4	204	9	0
Bench, ..	ditto,	”	29	3	2	0	0	6	2	58	6	0
ditto, ..	ditto,	”	29	3	1	9	1	0	2	102	4	6
Wing Wall, ..	ditto,	”	29	3	2	0	1	0	2	117	0	0
Pillar, ..	ditto,	”	7	0	4	6½	2	9	2	181	3	2
ditto Cornice, ..	ditto,	”	12	0	1	0	1	9	2	42	0	0
ditto, ..	ditto,	”	6	6	4	2½	2	6¾	2	146	2	3
ditto Cornice, ..	ditto,	”	9	0	0	3	0	9	2	3	9	0
Piers, ..	ditto,	”	4	1½	2	5½	4	6	9	411	10	6
Walls to crown of Arch, ..	ditto,	”	12	0	2	6	4	6	9½	1282	6	0
ditto, ..	ditto,	”	12	0	2	6	1	7	10	475	0	0
ditto, ..	ditto,	”	6	2½	4	1½	1	7	9	365	9	9
Arch, ..	ditto,	”	41	9	9	9	1	6¾	0	636	0	7
ditto, ..	ditto,	”	41	9	23	4	1	6¾	[illegible]	1522	1	5
								Total Contents,		8363	5	2

Deduct Piers, .. 1′ 1″ × 1′ 1″ × 1′ 7″ × 9 = 16′ 8″ 8‴
Do. Do., .. 1 1 × 1 1 × 4 6 × 9 = 47 6 6
Do. Do. Grooves, 1 0 × 0 9 × 1 7 × 9 = 10 8 3 — 74 11 5

Balance Total Cubic Feet of Masonry, ... 8288 5 9

16,992 Cubic Feet of Excavation done in making Roadway across arches, ... 177 × 32 × 3 = 16992 C. Ft. (L B D)

No. 2.—Excavation in Canal for Roadway.

	L		B		D	
Earth Excavated, ...	548·14	×	50	×	[illegible]	= 1,39,035 Cubic Feet.

No. 3.—Excavation for Channel of Earthern Aqueduct.

	L		[illegible]		D	
Earth Excavated, ...	4590·64	×	50	×	3	= 6,88,596 Cubic Feet.

No. 4.—Brick Kilns.

30,000 Pucca Bricks taken out of Kiln, ...	12″	×	6″	×	2½″
83,308 Peela Do. Do., ...	12	×	6	×	2½

No. 5.—Bridge Centres.

Centres, Planks, &c., all taken down and sent into store and planks all stacked at Shop.

No. 6.—Excavation for Embankment.

	L		B		D	
Earth excavated, ...	4353	×	25	×	4	= 4,35,300 Cubic Feet.

GANGES CANAL WORKS ——— DIVISION.

Abstract of Expenditure during the month of ——— 1847.

Description.	Rate.	Amount price.	Amount.	Total.	Grand total.
Work People.	*R. A.*				
280 Masons at per month,	8		74 10 8		
310 ditto .... ditto, ..	7-8		72 8 0		
70 ditto .. . ditto, ..	7		16 5 4		
2 ditto .... ditto, ..	4		0 4 3		
4 ditto .... ditto, ..	3-8		0 7 5½		
4 ditto .... ditto, ..	3		0 6 5		
24 ditto .... ditto, ..	2		1 9 7		
8 ditto .... ditto, ..	1		0 4 3		
19 Mistrees .. ditto, ..	9		5 11 2½		
21 Mates .... ditto, ..	8		5 9 7		
249 ditto .... ditto, ..	7		58 1 7		
434 ditto .... ditto, ..	6		86 12 9½		
46 Classies .. ditto, ..	4		6 2 1½		
25,160 Bildars .. ditto, ..	4		3,354 0 8		
4 Carpenters ditto, ..	10		1 5 4		
23 ditto .. . ditto, ..	8		6 2 1½		
18 ditto .... ditto, ..	7-8		4 8 0		
16 ditto .... ditto, .	7		3 11 2½		
2 ditto .... ditto, ..	6		0 6 5		
				3,704 9 0	
Materials withdrawn from store.					
66,308 2¼ inch pucca bricks, ..					
676 cubic feet Lime, ..					
676 cubic feet Soorkhi, ..					
676 cubic feet Sand, ..					
56 Govt. Bullocks in use,					
Materials purchased.					
1 seer Rope at 2 seers per rupee,			0 8 0		
6¼ seers Oil at 6¼ seers per ditto,			1 0 0		
74 Earthen vessels, each,	2 p.	72	2 0 10		
1,988 baskets at 2 Rs. per 100,			39 12 1		
				43 4 11	
Total expenditure, Company's rupees, ..					3,747 13 11

GANGES CANAL WORKS ——— DIVISION.

Account Current of Expenditure for the month of ——— 1847.

Date.		Dr.	Amount.	Total.	Date.		Cr.	Amount.	Total.
1847.		To Balance in hand on 1st —— as per last Account Current, ..	500 4 0		1847,	1	By Amount expended during the month of ——— as per Abstract, ...	3,747 13 11	
	17	To Cash received from ..	1,500 0 0			30	By Balance in hand, ...	252 6 1	
	20	To Ditto, ...	2,000 0 0						4,000 4 0
				4,000 4 0					
		Total Company's rupees, ..		4,000 4 0			Total Company's rupees, ...		4,000 4 0

APPENDIX F.

No. 360.

From

J. THORNTON, Esquire,

Secretary to the Govt., N. W. P.,

To

H. M. ELLIOT, Esquire,

Secretary to the Sudder Board of Revenue, N. W. P., Agra,

Dated, the 27th January, 1845.

Revenue Dept.

Sir,

With reference to the correspondence noted in the margin, * I am desired to request that you will inform the Board that the Lieutenant Governor, on the occasion of his late visit to Hurdwar, found that some difficulty and delay were still experienced in adjusting the amount of compensation for property required for the Ganges Canal. Advantage was taken of the presence on the spot of all the Local Revenue and of the Canal Officers, to come to a better understanding on the subject.

* Letter to Secy. Sudder Board of Reve., dated 4th June, 1844, No. 2111.
Letter from ditto ditto, dated 2nd July, 1844, No. 309.
Letter to ditto ditto, dated 20th July, 1844, No. 2726.
Letter from Comr. Meerut Division to Secy. Sudder Board of Revenue, No. 210, dated 24th July, 1844.
Letter to Secy. Sudder Board of Revenue, No. 3956, dated 7th Sept., 1844.

2. The great object to be attained is promptitude in the adjustment of all claims of this nature, and security that payment for property taken, or suspension of demand for land occupied, be not delayed when the right of the claimant has once been recognized.

3. These ends will generally be best attained by entrusting the award of compensation to the Canal Officers, who are on the spot, but it is found that, with regard to property in land, those Officers have difficulty in ascertaining the principles on which remission of the Government demand on the land is to be adjusted, or the persons who are entitled to claim the benefit of compensation on account of the land occupied by the Government. With respect therefore to this class of claims, the agency of the Collector must still be employed, and due provision made for fixing on the right party the responsibility for any delay which may occur.

4. The Lieut. Governor therefore proposes the following rules for adoption, and requests that they may be communicated through the Commissioner and Director of the Canals to those whom they may concern, unless the Board are aware of any objections to their immediate adoption.

5. The Canal Officers shall settle all compensation regarding houses, trees, crops, wells and buildings, and shall pay the money from their own Treasury, taking receipts as vouchers and acquittances from the owners. The Revenue Officers are always at liberty to represent any case in which they find the compensation awarded to be inadequate, or the proceeding to have been conducted in any objectionable way.

6. The Collector shall settle compensation regarding land, however occupied, whether by crops, or gardens, whether cultivated, culturable or barren, whether *khalisah* or *lakhraj*. In such cases, the Canal Officer as soon as he has laid down his line, (*takh bell*) should give certificates to the Tehseeldar and Collector stating the quantity of land he requires and which he has marked off, and the date on which he requires that it be vacated. This date should generally be that on which all the standing crops will be cut at the termination of the current Fussily year. It will then rest with the Tehseeldar immediately to ascertain and report to the Collector how and by whom the land is occupied, and on what terms remission of jumma or compensation should be given, under existing rules. It will rest with the Collector to provide that the terms be definitively settled by the time when the land is required by the Canal Officers, or as soon after as possible, and that no unnecessary demand is made on the Zumeendars for the land thus taken. The Collector, when reporting to the Commissioner his proposed remission for the confirmation of Government, will furnish a copy of his report to the Director of the Canal, in order that an opportunity may be afforded to that Officer of offering any remarks on the transaction that may occur to him as affecting the charge on his works.

7. The remission ultimately sanctioned by the Government will be notified to the Director of the Canal at the same time as to the Accountant, Revenue Department.

8. The Lieutenant Governor requests that the Board will impress upon the Commissioner and the Director of the Canal the importance of paying attention to the regular and punctual performance of this duty.

I am, &c.

J. THORNTON,

Secy. to Govt., N. W. Provinces.

Agra, the 27th Jany., 1845.

APPENDIX G.

Indent for Stationery required for the use of the Executive Engineer of the —— Division of the Ganges Canal, ———————— 1st July, 18—.

Names of Articles.	Received in December, 1846.			Balance on the 1st July, 1847.			Quantity Indented for, for 1848.			Number of Clerks, Assistants, &c.	Remarks.	Admitted.
	Rm.	Quires.	No.	Rm.	Quires.	No.	Rms.	Quires.	No.			
Double Elephant drawing paper,												
Book paper,												
General Letter paper,												
Foolscap paper,												
Quarto Post do.,												
Blotting paper,												
Serampoor paper,												
Marble paper,												
Cartridge paper,												
Quills,												
Black Ink powders,												
Red Ink powders,												
Penknives,												
Erazers,												
Hones,												
Strops,												
Slates,												
Scissors,												
Office Pencils,												
Drawing Pencils,												
Red Tape,												
Indian Rubber,												
Chest Inkstands,												
Round Rulers,												
Wafers, boxes,												
Wafer Seals,												
Sand, Europe,												
Pumice,												
Paste Boards,												
Camel hair Pencils,												
Crimson Lake,												
Prussian Blue,												
Gamboge,												
Burnt Sienna,												
Indian Ink,												
Books, Genl. Letter, &c.												

(Signed) ————————

EXECUTIVE ENGINEER,

Division Ganges Canal.

APPENDIX H.

Authoritative decisions on certain points submitted by Executive Officers.

QUESTION. *Lieut. Strachey's letter No. 53 of 20th June, 1843. Enquires how he is to obtain the cost of packing cases sent with stores from magazines, how it is to be debited, and what is to be done with the articles themselves? Also, in case he is directed to sell them, how the amount should be charged in his accounts?*—ANSWER. Secretary Military Board's letter No. 1939, of 22nd July, 1843, states, "that it would probably be the best plan to sell the packing cases in question, if they are not required in the department, and Lieut. Strachey might indemnify himself for any loss in the sale by submitting a bill for the difference, and the proceeds might be brought forward in the periodical account current." "Lieut. Strachey can be furnished from the Board's office with the rates of any articles supplied to him from the Ordnance Department, whenever applied for."

The plan generally adopted is to return to the magazine all the packing cases, &c. received, and to submit a bill for their value, supported by the Magazine Officer's receipt.

QUESTION. *Lieut. Strachey's letter No. 49 of 30th May, 1843. Understands that Major Cautley had proposed to Government, the employment of public cattle on the Ganges Canal works, for the conveyance of materials; such a measure being undoubtedly a great saving, requests that he may be informed of the decision of Government on the subject,*—ANSWER. Commissary General's letter No. 1173, dated 9th June, 1843, protests against the proposed measure as being most inexpedient at any time. "We have no carts to give, but if our Elephants and Camels are so employed, there would be few or none amongst them, with sound backs in the course of a month."

"The objection applies to a particular employment, and holds good not only now, but at all times."

The above view was concurred in by the Hon'ble the Lieutenant Governor, N. W. P. Vide Secretary's letter No. 3706 of 15th August, 1843.

QUESTION. *Major Baker's letter No. 389 of 1st April, 1845, enquires 1st, "whether in the prosecution of public works it be necessary that the undermentioned documents should be engrossed on stamped paper, vizt. contracts or agreements for excavation of*

earth, manufacture of bricks, or supply of materials, and security bonds for the repayment of Government money advanced on the above account; 2ndly, whether in the event of the documents above mentioned being engrossed on other than stamped paper of the prescribed value, the Executive Engineer can, in a Civil Court, enforce the fulfilment of a contract, or recover the amount of security, when justly forfeited; or, in other words, 3rdly, whether the general exemption appended to Regulation X. of 1829 be intended to apply to the Department Public Works?—Answer. The Secretary to the Government N. W. P. in his letter No. 2166 of 1845, dated 23rd May, 1845, to the Military Board states in reply "that the exemption which follows article 12, Schedule A. Regulation X. of 1829 (as copied in the margin*) is in his Honor's opinion entirely applicable to the documents mentioned by Captain Baker. His Honor therefore conceives that there is no necessity for executing such documents on stamped paper.

* Bonds given to or by the officers of Government on account of any matter or thing of or belonging to the Government in its political or territorial capacity.

Question. *The Superintendent of Canals, having granted to Commissioned Officers, in the Canal department, temporary leave of absence on private affairs,*—Answer. The Board, in their Secretary's letter, No. 3565 of 7th September, 1847, ruled "that the only pleas, under which a Superintending Engineer can, under existing orders, grant leave, are first on Medical certificate, and in such case the party should furnish the requisite certificate, and secondly, on urgent private affairs, in which case the Superintending Engineer must satisfy himself of the validity of the plea before granting it.

Question. *Major Baker's letter No. 1472 of 10th April, 1847, enquires the power vested in him to grant leave of absence to uncovenanted subordinates in the Canal department,*—Answer. Secretary Military Board's letter No. 1600, dated 25th June, 1847, transmits copy of a letter No. 2448 of 10th idem, with annexures from Mr. Secretary Thornton, "communicating the power vested in you by Government to grant leave of absence not exceeding one month in each year, over and above the occasional holidays, whenever you are of opinion that the indulgence can be granted without detriment to the public service, and is merited by the good conduct of the applicant."

Question. *Lieut. Strachey's letter No. 105, dated 24th October, 1845, asks for permission to advance to Asst. Overseer Sergt. Johnstone the sum of 200 rupees to assist him in building himself a bungalow at Roorkhee,*—Answer. The Secretary Military Board's letter

No. 6223 of the 16th December, 1845, states, "that an advance of 200 rupees requested by Sergeant Johnstone, to enable him to build a house at Roorkhee, is quite inadmissible."

QUESTION. *Lieut. Smith's office and private carriage having been seized for military purposes and a complaint made,*—ANSWER. The Hon'ble the Lieutenant Governor replied, in Mr. Secretary Thornton's letter, No. 4853 of 11th November, 1846, that "when absolutely required for the march of Troops, the seizure of carriage is authorized by Regulation XI. of 1806, Section 3."

QUESTION. *Lieut. Turnbull's letter No. 225, dated 10th June, 1847, requests that sanction may be obtained, for placing the whole of his Bricks under charge of the Civil village powers, as he is anxious to remove his establishment,*—ANSWER. The Commissioner of Meerut, in reply (No. 257 of 14th June, 1847,) states that he has directed the Collectors of Meerut, Mozuffurnuggur and Saharunpoor, "to provide for the protection of the bricks by making the Zumindars of the villages where they are collected, responsible for their safe custody. The village Chokidars ought likewise to be ordered to look after the heaps, and see that they be not pilfered by the inhabitants of the neighbourhood."

QUESTION. *Reference having been made regarding a statement of conditions of service of Bildars &c. employed on the Ganges Canal Works,*—ANSWER. The Hon'ble the Lieutenant-Governor decided (in Mr. Secretary Thornton's letter No. 617 A. of 1847), dated 29th September, 1847, that he could "only refer you to Sections 5 and 6 Regulation VII. of 1819, and to the constructions of the Nizamut Adawlut noted in the margin,* which have reference to that enactment. By the two first, you will see that European British subjects are held not to be liable for prosecution as defendants under the Regulation in question, though they may sue as complainants; and by the last you will perceive that there must be either a stipulated term of service, or a contract for specific work, to render artizans and other workmen liable under Section 5, of the Regulation."

* No. 340 dated May 25th, 1821.
34[illegible] dated July 20th, 182[illegible].
38[illegible] dated April 29th, 1825.
1329 dated May 27th, 1842.

"The Lieutenant Governor does not consider that there would be any difficulty in your having a simple form of agreement drawn up and lithographed, to which every laborer employed on the Canal should be required to subscribe. In this contract the forfeiture of arrears for a certain period might be made the stipulated penalty of absconding without due notice. The conditions of such an engagement would necessarily become in a short time generally known."

In accordance with the above suggestion, an agreement paper has been drawn up and adopted in the northern division, a copy of which is hereto annexed.

Copies of the sections and constructions above referred to are also attached.

Form of Agreement Paper.

هم که سب ٹنڈیل اور بیلدار نوکر علاقه نهرگنگ ضلع اوتر کے هیں

جو هم سب بیلدار نوکر نهرگنگ ضلع اوتر کے هیں اسواسطے اقرار کرتے هیں اور لکهدیتے هیں که هم لوگ همیشه موافق دستور نوکروں کے وقت ضرورت آئیندگی اگر نوکري چهوڑنا چاهیں تو پندره دن پہلے خبر چهوڑنے نوکري مذکور کي بحضور صاحب بهادر مهتمم نهرگنگ کے کریں اور جوکوئي هم میں سے بسبب سستي کام یا شرارت اپني کے کار سرکار چهوڑکر بیٹهه رهے یا بدون پندره دن پہلے خبر دینے کے نوکري چهوڑکر کهیں چلا جاوے تو تنخواه چڑهي هوئي اُسکي دو مهینے تلک کي سرکار میں ضبط هوجاوے اور اگر بابت اُس تنخواه کي وه شخص پهر کبهي دعوی کرے تو جهوٹها هو اور جو واجبي حصه کام طرف صاحب بهادر مهتمم نهرگنگ سے مقرر هوجاوے وه کام هم پوراکردیں یهه شرط نوکري اور ٹهیکه کام همارے کي هی اسواسطے یهه چند کلمه بطریق اقرار نامه کے لکهدئیے که سند هووین اور وقت حاجت کے کام آوین • تحریر بتاریخ

Sections 5 and 6 of Regulation VII. *of* 1819.

V.—All persons who may voluntarily engage to serve as workmen of any description for a stipulated term, or who may voluntarily contract for the performance of any specific work, and who without good and sufficient cause shall wilfully quit the service so engaged for, before the expiration of the term agreed upon, or shall wilfully neglect to perform the work so contracted for, shall be deemed guilty of a misdemeanour; and on conviction, before a Magistrate or Joint Magistrate, shall be liable to a sentence of imprisonment, not exceeding one month. The Magistrate or Joint Magistrate may likewise require the persons so convicted to complete their stipulated term of service, or to perform the work contracted for if it appear just and proper to require the same; and any subse-

quent conviction of wilful neglect to comply with such requisition shall be punishable by a further sentence of imprisonment, not exceeding two months.

VI.—Clause First.—The provisions of the foregoing Section are also declared applicable to domestic servants, who may engage to serve for any fixed term, or during the performance of any specific service, or though no such engagements have been entered into, may be employed from month to month, and without good and sufficient cause, shall wilfully quit the service of their employer before the expiration of the fixed term, or before the completion of the stipulated service, or with respect to monthly servants, without giving previous notice for a period not less than fifteen days.

Second.—In like manner, no master, or other person, employing a servant for a fixed term, or for a specific service, or from month to month, shall be at liberty without good and sufficient cause, to discharge such servant against his will before the expiration of the fixed term, or the completion of the specified service; or, with respect to servants employed from month to month, without giving previous warning of the intended discharge for a period of at least fifteen days, or paying his wages for that period.

Third.—It shall be the duty of the Magistrate or Joint Magistrate, on application made to him upon the stamp paper prescribed in Section 18, of Regulation I. 1814, (vizt. bearing a stamp of eight annas) to enforce the provisions of the above clause, by causing payment to any servant who may be discharged in opposition thereto, of a sum equal to half a month's wages, in addition to any arrear of wages which may be due to him at the time of his discharge, or if the servant have been engaged for a fixed term, or for a specific service, by causing payment to be made to him of such sum as may appear fully adequate to any loss sustained by him from being discharged before the time agreed upon.

Fourth.—Provided, however, that no servant shall be entitled to recover more than his arrear of wages when he may be discharged for misconduct proved to the satisfaction of the Magistrate or Joint Magistrate, and appearing sufficient to warrant his discharge, nor shall any workman or servant, be liable to punishment under the provisions of this Regulation, when it may be proved, to the satisfaction of the Magistrate or Joint Magistrate, that his quitting the service of his employer, without previous notice or before the expiration of a stipulated term or without having completed the performance of any work contracted for, was occasioned by gross mal-treatment, or by non-pay-

4

ment of wages due, [redacted] by any other cause which may appear to the Magistrate [redacted] Joint Magistrate, sufficient to justify or excuse the act complained of.

VII.—The whole of the sentences which may be passed by [redacted] Magistrate or Joint Magistrate under any part of this Regulation will of course, be open to the regular control of the Court of Circuit of the division, according to the general rules [redacted] force [redacted] this subject.

CONSTRUCTIONS OF THE NIZAMUT ADAWLUT.

To the Bareilly Court of Circuit,

Dated the 25th May, 1821.

No. 340, 1819, Reg. VII., Sec. 6, Cl. 3.

I am directed by the Court of Nizamut Adawlut to acknowledge the receipt of [redacted] letter from you, dated 11th instant.

2nd.—In reply, I am directed to communicate to you the opinion of the Court, that the Rule contained in Clause 3, Section 6, Regulation VII. 1819, cannot be considered applicable to European British subjects, and that consequently, under the general Regulations, [redacted] award by a Magistrate, (even though a Justice of the Peace) of the nature alluded to in the latter part of the first paragraph of your letter, is unauthorized and illegal.

3rd.—You are of course at liberty to consult the Advocate General, as to how far he may consider such [redacted] decision legal under the Act of Parliament, to interpret which does not [redacted] within the province of this Court.

4th.—It [redacted] at the [redacted] time obvious to remark, that from [redacted] conviction of a British subject by [redacted] Magistrate, in his capacity of Justice of the Peace, under 53rd George III., Cap. 155,* *the appeal is not* [redacted] *a Court of Circuit, but to the Supreme Court in Calcutta.*

To the Bareilly Court [redacted] Circuit.

Dated the 20th July, 1821.

[redacted] 345, 1819, Reg. VII. Sec. 6.

I [redacted] directed by the Court of Nizamut Adawlut to acknowledge the receipt of a letter from you under date the 2nd instant, together with its enclosure from the Magistrate of Zillah Moradabad, dated the 27th ultimo.

* This is superseded by [redacted] Regulation which vests the Appellate power in [redacted] Court.

2nd.—The rule contained in Clause 3, Section 6, Reg. VII. of 1819, being clearly not applicable to European British subjects as defendants, and it appearing from Mr. Halhed's letter to your Court, that he is in possession of a copy of my letter to your address, bearing date the 25th May last, the Court are not aware of the necessity of any further orders on the subject of Mr. Halhed's enclosure in your letter above acknowledged. With respect to the query occurring in the second and at the conclusion of the third paragraph of Mr. Halhed's letter, it is obvious, that Clause 4, Section 16, of the above cited Regulation, cannot be acted upon at all against such masters or persons, as may not be liable to the Regulation and subject to the Magistrate's authority; at the same time, that against such servants as are liable and subject, the Regulation may be acted upon, even in favor of those very masters who are exempted from being made defendants.

To the Acting Magistrate of Zillah Sylhet,

Dated the 29th April, 1825.

No. 584, 1819, Reg. VII. Sec. 5.

The Court of Nizamut Adawlut have had before them your letter, under date the 16th instant; requesting to be informed whether the second punishment directed by Section 5, Regulation VII. 1819, in cases of workmen neglecting to finish their work, should be considered final and conclusive, or whether the Magistrate is at liberty to repeat such punishment until the work is performed.

2nd.—In reply, I am desired to communicate to you the opinion of the Court, that the sentence of two months' imprisonment, prescribed in the Section above quoted, is intended as punishment for wilful neglect to perform work undertaken, and not as a means of compelling the performance of it; consequently, that the Magistrates are not competent to repeat the punishment of two months' imprisonment or to take any further measures towards compelling an actual performance of the work engaged for.

No. 1329. 1819, Reg. VII. Sec. 5 and 6.

The following Queries were submitted by the Magistrate of the 24-Pergunnahs, to which the replies in juxtaposition were given :—

Questions. *1st.—Can workmen, such as Mistrees, Moochees, or other Artizans, be brought within the meaning of the enactment*

quoted, supposing that they have taken advances from their employers and agreed to work for the same, without any stipulation as to the precise term or specification of the job that they are to perform?

2nd.—By what Magistrate are cases, under the above mentioned provisions, cognizable: the Magistrate of the district wherein the agreement was entered into, or that of the district wherein the delinquents reside, or to which they may have decamped?

Answers. 1st.—There must be a stipulated term of service, or a contract for the performance of specific work, to render Section 5, Regulation VII. 1819, applicable to the cases alluded to.

2nd.—Such cases may be prosecuted either in the district in which the agreement was executed, or in that in which the defendant resides.

Calcutta Court, 18th March: Western Court, 27th May, 1842.

APPENDIX
E

Ganges Canal Appendix
sig. J Vol III

[illegible]

[illegible] 1858.

[illegible]

[illegible] the [illegible]

[illegible] that [illegible]

[illegible] that [illegible]

[illegible] the [illegible]

[illegible] left by [illegible]

out. The Boorma nulla has been deepened to suit the level of the works.

2. [illegible] foundations and floor of the [illegible] Dam have been completed, and a portion of the East and West [illegible] has also been built. [illegible] the Dam and the attached sluice work are [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the canal supply. The deviations from the original design of this work are as follows.

Cross foundations connecting the front and rear [illegible] walls have been added under every 4th Pier and the floor has been made of stone [illegible] [illegible] [illegible] [illegible] [illegible] during floods. The edges of the floor are [illegible] [illegible] [illegible] the [illegible] is [illegible] instead of [illegible] [illegible] together [illegible].

The [illegible] Regulating Bridge has been [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] completed to [illegible] of the [illegible] of the [illegible]. The deviations from the original design for this work are as follows. The foundations of the [illegible] have been carried down to the same depth as those of the front and rear [illegible] walls. The length of the Piers has been increased [illegible] feet. The [illegible] both up and down stream having been built beyond the floor instead of on it. A stone floor similar to that of the Dam has been substituted

[illegible] on the brick counter arches is pro[illegible] posed, [illegible] the [illegible] of the piers have been [illegible] [illegible] Iron. [illegible] reason for [illegible] ing the width of the piers is to allow more room for [illegible] the stone pieces [illegible] that will [illegible] the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] [illegible] to [illegible] this purpose that [illegible] gates [illegible] [illegible] [illegible] that they should be [illegible] [illegible] [illegible] thickness to resist the pressure at different depths [illegible] that they should [illegible] [illegible] [illegible] the piers [illegible] [illegible] [illegible] the [illegible] width of the [illegible]. [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] from the [illegible]. [illegible] was [illegible] feet, the latter [illegible] having been considered sufficient [illegible] for the [illegible] with the [illegible]. The [illegible] was at first built of [illegible] timber as a [illegible] [illegible] plan, but it was found that the floor though [illegible] with the longest [illegible] [illegible] [illegible] to withstand the impact of boulders [illegible] falling vertically [illegible] feet, and the form of the [illegible]

was subsequently [illegible] by Lieutenant [illegible].

[illegible] a complete [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible]

[illegible]

[illegible] the [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] and Christian [illegible] the [illegible] was [illegible], but [illegible] it not desirable at present that the [illegible] discharge [illegible] should be [illegible] into the Canal, they are [illegible] across the channel between

embankments

[illegible] Government. [illegible] the recently [illegible] catastrophe [illegible] the [illegible] Government [illegible] of these [illegible] The bridge will [illegible] 15 inches [illegible] the ground [illegible] that the whole [illegible]

[illegible] of the [illegible] The [illegible] of [illegible] is much the same as that [illegible] completed [illegible] obtaining water for this [illegible] as for the bridges [illegible]

The [illegible] [illegible] [illegible] [illegible] being [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the Channel [illegible] [illegible] by [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the [illegible] [illegible] of the [illegible] across the [illegible].

6. [illegible] [illegible] of the [illegible] Channel between [illegible] [illegible] the [illegible]

a b. [illegible] [illegible]
[illegible] [illegible]
[illegible] [illegible]
[illegible] that of c d e. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible].
[illegible] [illegible] [illegible] [illegible] effectual during night [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible]. [illegible] making a slight [illegible] at d. [illegible] [illegible] the effect of holding up a body of water sufficient [illegible] [illegible] [illegible] [illegible] [illegible] and a large [illegible]. The method adopted, one which certainly answered well during the last [illegible] season was to form

Open

[illegible] reports in the [illegible] of masonry [illegible] the [illegible] de [illegible] to [illegible] the tunnel [illegible] points, [illegible] the surface [illegible]

b.c.d. [illegible] would [illegible] reports are made of [illegible] [illegible] slight dimensions, [illegible] intended to be permanent.—

5. [illegible] permanent [illegible]

[illegible] larger [illegible]

[illegible] may be afforded by [illegible]

[illegible] of the [illegible] line.

6. [illegible]

[illegible] the [illegible]

[illegible] the [illegible] bank [illegible] by a [illegible] the bot- tom of the Canal.— [illegible] Dams would be [illegible] to [illegible] limited [illegible] of [illegible] lines, the [illegible] planked up would [illegible] the Canal supply— and the tunnel would carry [illegible] leakage through the upper Dam, and the natural stream of the River.

7. [illegible] deep drainage of [illegible]
[illegible] [illegible] and
it had [illegible]
[illegible] the [illegible]
[illegible] had [illegible]
because [illegible] [illegible]
[illegible]
done [illegible]
the [illegible]
[illegible]
labo[illegible] [illegible]
8. [illegible]
drain[illegible] [illegible]
[illegible]
the [illegible] Enclosure[illegible] [illegible]
[illegible] that [illegible]
should [illegible] [illegible] not
[illegible]
[illegible]
[illegible]
[illegible]
higher than [illegible]
the native [illegible]
[illegible] from [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
that [illegible]
[illegible] the [illegible] system.
9. [illegible]

had

[illegible] of the [illegible] [illegible]

[illegible]

the passage [illegible] the [illegible]

[illegible] this [illegible]

is [illegible] properly [illegible]

[illegible]

[illegible]

stability [illegible]

11. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] the [illegible]

Masonry [illegible]

[illegible] the stability [illegible]

Labourers not been employed [illegible]

[illegible]

[illegible] discharged [illegible] must [illegible] collecting [illegible]

[illegible]

19. [illegible]

[illegible] that [illegible]

[illegible] field, [illegible]

[illegible]

18. [illegible]

[illegible] supposed [illegible]

[illegible] is to [illegible]

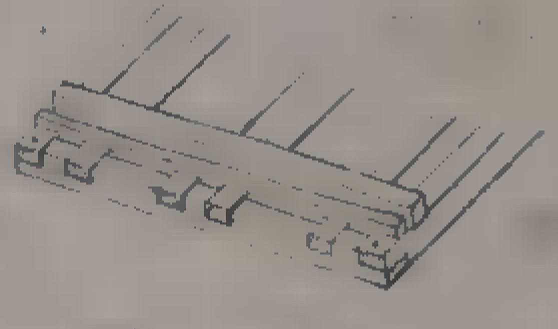
[illegible]

are 22' long, 22' wide and 22' deep, and the spaces between them are exactly equalized.

The plan and disposition [illegible] Rock [illegible] and [illegible] of the [illegible] to the [illegible] of the [illegible]

[illegible]

[illegible]



[illegible]

a hollow [illegible]

rule was observed in laying these frames and it so happened that those in the line of the first piers were placed with the hollow side outwards, and the third did not so each [illegible] but when the [illegible] sinking commenced the [illegible] of this arrangement became apparent. The flush sides being deeper in the soil [illegible] the block [illegible] the sand; constantly flowed in through the hollows and really [illegible] the process of sinking. In the next pier the [illegible] of the frames was altered, the flush sides being placed outside and the hollows [illegible] the [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] is this difference [illegible] the sinking of the 1st pier was [illegible] than that of the other.

[illegible] [illegible] [illegible] [illegible] frames, [illegible] [illegible] [illegible] [illegible] arising from weakening of the [illegible] the external pieces only [illegible] [illegible] [illegible] [illegible].

19. [illegible] of the [illegible] [illegible] [illegible] of hoop-iron [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] alternate [illegible] [illegible] the [illegible] [illegible] the curb frame.

20. In consequence of the strength of the curb framed and the use of hoop-iron, the occurrence of cracks in the [illegible] during the process of sinking had been very [illegible] [illegible] [illegible] one or two blocks which had been

delivered by floods making through the Coffer Dam.—

21. [illegible] undertakings [illegible] effected almost [illegible] with [illegible] machinery worked by [illegible] at the end of [illegible]. [illegible] machinery [illegible] Spokes.

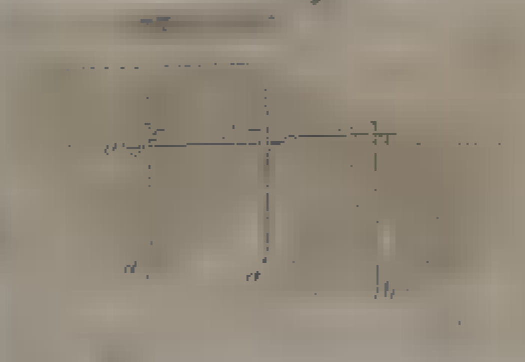
[illegible] Compared [illegible] not less [illegible] [illegible] sufficient [illegible]

22. [illegible] the [illegible] from the [illegible] [illegible]

23. [illegible] [illegible] the principal [illegible] Coffer Dam [illegible] channels [illegible] the flood [illegible] of the River.—

24.

24. The Coffer Dam consisted of two [illegible] 12' and 15' [illegible]



[illegible] piles [illegible] affords [illegible] [illegible] by cross [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

25. [illegible] Com[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] have [illegible] the floods of [illegible] water. [illegible] has not [illegible] within it, remain[illegible] [illegible] community be

executed during the ensuing rainy season — and in the mean time, as much work will be commenced outside the [illegible] as there is reason to hope [illegible] before the 1st of June.

2d. [illegible] that the [illegible] is less than the [illegible] of the [illegible] in the line laid down for the Canal, [illegible] be necessary [illegible] that part of the [illegible] will be [illegible] of the [illegible] that the [illegible] should be [illegible] the [illegible] line.

3d. [illegible] that [illegible] for [illegible] the exact [illegible] on the selected line, [illegible] with such [illegible] of the [illegible] brought down for specimens as the [illegible] through [illegible]

4th. [illegible] be made to the discussions which have arisen [illegible] the thickness of [illegible] of the [illegible] [illegible] and [illegible] [illegible] the [illegible] [illegible] Continents [illegible]

[illegible] weak. and that they should have at —
least 12 feet of thickness with counterforts.
Mr F. W. Simms [illegible] was subsequently con-
sulted. [illegible] [illegible] thickness with
counterforts. The [illegible] walls [illegible] proposed by
[illegible] before this [illegible] was [illegible] with —
[illegible] of [illegible] of [illegible]. Counter-
forts if necessary may be added. but I would
[illegible] that [illegible] in [illegible]
[illegible] direction of the thrust. It appears to
[illegible] that [illegible] Colonel Abbott and
Mr Simms [illegible]
the [illegible] of the [illegible].

30. [illegible] been
[illegible] have made
[illegible] consists
[illegible] flight of steps —
[illegible] walls is 15 feet.
[illegible] 131 feet between
them. [illegible] of the [illegible]
a flight of steps as in the [illegible]
[illegible] supporting the [illegible]
[illegible]
[illegible] of the [illegible] which we have
partly because [illegible]
[illegible]
[illegible]

[illegible] of [illegible]
[illegible]
springing from unequal —
heights like that of a flying buttress. [illegible]
walls are connected with each other [illegible]

bottom, but they [illegible] made [illegible]. [illegible] cross walls are built between them at distances of 15 feet apart.—

31. The material used in the Reservoir is not all of such good quality as that selected for the Aqueduct. In the cross walls and in the inner faces of the [illegible] walls some second class bricks have been used. The exposed surfaced, arched [illegible] made of the best bricks [illegible] [illegible] [illegible] also [illegible] [illegible] the [illegible] bricks [illegible] [illegible] [illegible] [illegible] [illegible] height [illegible] brick.— 13/-2

32. [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] bricks are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

33. [illegible] [illegible] [illegible] [illegible] extended [illegible] the [illegible] of the [illegible] provided for that purpose [illegible] [illegible] the [illegible] Room, but still not afford sufficient accommodation. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] having been [illegible] from their allotted [illegible] [illegible] now [illegible] [illegible] both within and without the workshop [illegible].—

34. The possession of an efficient workshop has enabled us, not only to prepare the implements

implements absolutely needing [illegible] carrying on the [illegible] but to [illegible] [illegible] [illegible] [illegible] on the public buildings [illegible]. [illegible] these [illegible], [illegible] [illegible] enumerated [illegible] for the [illegible] [illegible] for Water, [illegible] [illegible] [illegible] [illegible] the Birch [illegible], [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible], [illegible] [illegible] for the [illegible] [illegible] [illegible] for the [illegible] [illegible], [illegible] [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] supply of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] subject [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] purpose [illegible] to the
to the brick. During the [illegible] part of the [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
the [illegible] these [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the
method of burning bricks with [illegible], [illegible]
practised at [illegible] [illegible] [illegible] [illegible] [illegible] but [illegible]
people did [illegible] [illegible] [illegible] [illegible] with the [illegible]
of burning the [illegible] [illegible], and [illegible] [illegible]
[illegible] with [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
weather, and the [illegible] of the ground.
[illegible] the [illegible] of the [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] with the
[illegible] [illegible] [illegible] the [illegible] [illegible] [illegible]
chances for the [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] accomplished, [illegible] [illegible] [illegible] with better
success, and before the [illegible] of the [illegible],
[illegible] had [illegible] [illegible] about 3 [illegible] [illegible] [illegible]
[illegible] bricks from the [illegible] [illegible] [illegible] [illegible]
[illegible] of the present [illegible] the [illegible] mak-
ing [illegible] [illegible] [illegible] [illegible] the [illegible]
[illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the
[illegible] [illegible].
26. [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible], [illegible] these [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attention
having

[illegible]

38. [illegible]

39. [illegible]

[illegible] first is often used [illegible] with us, because it completely frees the [illegible] [illegible] [illegible] [illegible] the 1st [illegible] satisfactory.

[illegible] 3rd. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] this [illegible] [illegible] the 4th [illegible]

[illegible]

[illegible] [illegible] quality [illegible] [illegible] [illegible] [illegible] important [illegible] [illegible] tried.

40. [illegible] Powers [illegible] Sept. 20/47

may be considered as experimental the expenditure was 54,500 Rs paid, the result 38 Lakhs of Bricks or about Rupees 1435 per Lakh. During the present season, so far as it has gone, the [illegible] were [illegible] about 1000 Rupees per Lakh, but [illegible] in [illegible] [illegible] [illegible] [illegible] to [illegible] Rupees per Lakh. From this [illegible] [illegible] that the cost [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

41\. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] have been [illegible].

42\. [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] necessary to modify the [illegible] [illegible] [illegible] [illegible]. This necessity [illegible] partly [illegible] [illegible] in the [illegible] ([illegible] [illegible] [illegible]) and partly because the [illegible] [illegible] was not sufficient [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] of the Medical Committee.

the

In two places_ viz^t between [illegible] and [illegible]_ and between the latter place and [illegible]_ there was not more than from 0 to 3½ feet of [illegible] which would have left the full water surface [illegible] of the Canal 6½ to 10 feet above the surrounding [illegible]. [illegible] are above [illegible] to occur in a manner not easily accounted for. [illegible] of the Country along the proposed line have been repeatedly and [illegible] accurately taken [illegible] have been compared with [illegible] [illegible] marks [illegible] satisfactory. [illegible] taking [illegible] the [illegible]. [illegible] [illegible] the [illegible] [illegible] the [illegible] length [illegible]. [illegible] of the [illegible] [illegible] that [illegible] have been [illegible] labourers [illegible] the [illegible] of the [illegible] of the Canal_ [illegible] be [illegible], [illegible] Director of the [illegible], [illegible] of the blame [illegible] failing to check the [illegible] as [illegible] in the levels....

43. [illegible] of the bottom [illegible] has [illegible] effected [illegible] a fall of 3 feet at the [illegible] Bridge [illegible] that at [illegible] results of this [illegible] effects [illegible] its [illegible] of the [illegible] complete [illegible] although [illegible] would have been [illegible]

44. [illegible]

[illegible]

45. [illegible] the [illegible] to the [illegible] curve the canal is [illegible], the [illegible] made, and [illegible] bollards built at [illegible] intervals. —

46.

46. [illegible] of the [illegible]
[illegible] of this
[illegible] that [illegible] of the
[illegible]
is [illegible]
[illegible] of the
[illegible]
[illegible] The
[illegible]
[illegible] the purpose
[illegible]
[illegible] for them
[illegible]
[illegible]
47. [illegible]
[illegible]
[illegible]
by the [illegible]
[illegible] would be
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] that the [illegible] of the
[illegible]
[illegible]
[illegible] have
[illegible] a less fall than that of the Country

[illegible]
water [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
19 [illegible]
[illegible]
most [illegible]
[illegible]

48. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

49. [illegible]
[illegible]
[illegible]
[illegible]
[illegible] purposes [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
3 [illegible] purposes [illegible]
[illegible] 150 [illegible]

50. Of the [illegible] Sulphur [illegible]

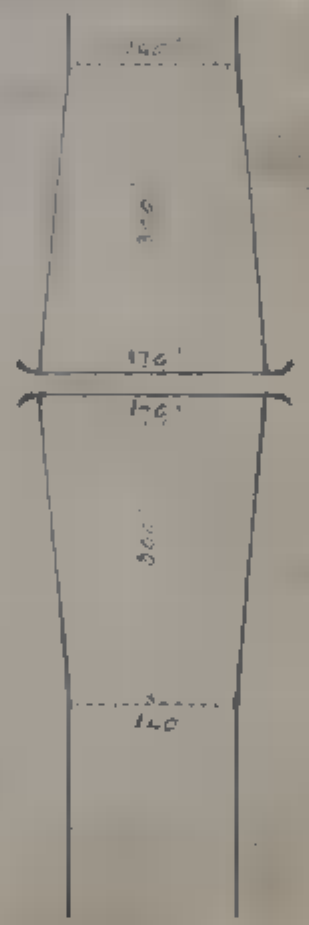
The

[illegible] 91

the [illegible] feet [illegible] the [illegible]
[illegible]
[illegible] of the
[illegible] been [illegible]
[illegible] which

[illegible]

[illegible] of the
[illegible]
[illegible] side



[illegible] the [illegible]
[illegible] 177' [illegible]
[illegible] bottom [illegible]
[illegible]

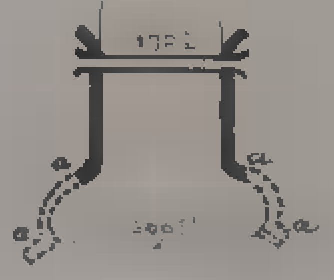
The width [illegible]
[illegible] is 172½ feet [illegible]
wide, is [illegible] accommodated

do the width of the canal. Below [illegible]

[illegible]

adopted [illegible]

[illegible]



the [illegible]

Fig. 11.

[illegible]

of the [illegible]

52. [illegible]

[illegible]

53. [illegible]

[illegible]

important to him [illegible] to be done, [illegible] in as [illegible] as possible [illegible] [illegible]
drawn the [illegible] of the [illegible]
in attendance [illegible]
[illegible]
economy [illegible]
[illegible]
[illegible]
[illegible]
the [illegible]

[illegible]

APPENDIX F

CALCULATIONS FOR DISCHARGE

The following points being conceded as axioms, the data for the discharge, and the capacity of the Canal channel have been framed upon them:—

1st. That a discharge of 1 cubic foot per second constant, is equal to the irrigation of 350 beegahs of 55 yards square each.

2nd. That from the results of the Delhi and Doab Canals 800 cubic feet per second constant, is a fair supply for irrigation for 100 miles in length of a Canal.

3rd. That taking [illegible] collectively, with reference to their general [illegible] character, a proportion of surface equal to one-third of the whole, is a fair proportion requiring irrigation.

2. On each 100 miles in length therefore, the Canal would on the 2nd axiom, irrigate 280,000 beegahs = 273·4 square miles, and on the 3rd axiom this would be sufficient for an area of country equal to three times that amount, or to 820·2 square miles.

3. Assume therefore that a strip of country on each side of the Canal from 4 to 5 miles, say 5 miles in width, would be irrigated. The beneficial effects of irrigation being open to distant lands, when those in the immediate neighbourhood of the Canal were not suited to irrigation.

[illegible]

proposed [illegible] direct line from Hurdwar to Allahabad. The total distance being 453 miles, from this main line branches will be taken off towards Futtegurh, [illegible] the Bolundshuhur District, Etawa and Cawnpore.

5. The first part of the canal, or that from Hurdwar to the village of Nessinpoor 27½ miles in length, may be considered as removed from the influence of irrigation from its passing through Khadir land in the early part of its course, and deep digging immediately above [illegible]; there remain then 425½ miles requiring an allowance of [illegible] feet of water for irrigation on the main line only.

6. The lengths of the branches are as follows:

Futtegurh	160 miles
Bolundshuhur	70 do
Etawa	172 do
Cawnpore	43½ do

For the first five miles of these branches, the canal may be considered as under the influence of the main line as far as irrigation is concerned; the total length of canal therefore, including both the main line and the branches, for irrigation must be provided for as follows:

Main Line	453	− 27½	=	425½	miles
Futtegurh Branch	160	− 5	=	155	do
Bolundshuhur do	70	− 5	=	65	do
Etawa do	172	− 5	=	167	do
Cawnpore do	43½	− 5	=	38½	do
Total number of miles				851	

By referring to the Sheet of Sections of the main line, it will be observed that throughout the [illegible] of the Futtehpore and Allahabad Districts, or on the last 100 miles approaching the terminus, the excavation of the Canal channel is so deep, that although cuts may be taken off at right angles for the purposes of irrigating distant lands, the fields in the immediate vicinity of the Canal will be difficultly supplied with water, and that only by machinery. I have therefore reduced the supply of water for irrigation on the lower tract from 8 to 4.92 cubic feet per second for each mile — turning the difference to a more useful account in the Cawnpore District.

7. The distribution of the whole body of the Canal supply therefore, which is calculated at 6750 cubic feet per second, and which is supposed by the Committee to reach the high lands of the Doab at Roorkee, will be thus —

Main Line —	425½ miles	325½ at 8 cub. ft per mile	2604
		100 at 4.92 do do	492
		Total for Main Line	3096
Futtehgurh Branch,	155 miles	at 8 cub. ft per mile	1240
Bolundshuhur do	65 do	do	520
Etawah — do	167 do	do	1336
Cawnpore — do	38½ do	do	308
Reserved portion for navigation at Allahabad			250
		Grand total	6750

8. The table of discharges at the heads of branches, with that for the computation of the capacity of the main channel, and transverse sectional area of excavation will be thus—

1st Distance from the head at Hurdwar to the departure of the Futtehgurh Branch . . . 50 miles
2nd Futtehgurh Branch head to Bolundshuhur Branch . . . 100 do
3rd Bolundshuhur Branch to Etawa Do . . . 70 do
4th Etawa Branch to Cawnpore Do . . . 100 do
5th Cawnpore Branch to Jumna at Allahabad . . . 17[illegible] do

Total Length . . . 4[illegible] miles

As noted in the 6th paragraph of this Appendix, 27½ miles must be deducted from the first item, leaving 22½ out of the 50 miles to be supplied with water for irrigation. From this results the following table:

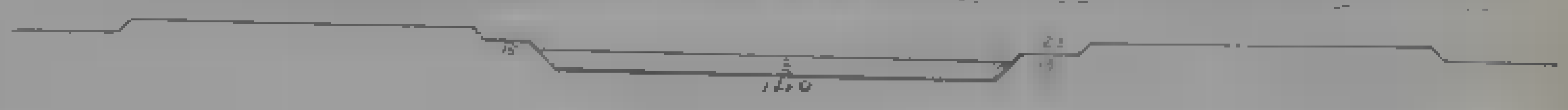
Junctions on the Main Canal to below	Water demanded for Irrigation: Main Line	Branch	Discharge below Branch in the Main Line
Futtehgurh Head	6750 −	(180 + 1240)	= 5330
Bolundshuhur Do	5330 −	(480 + 520)	= 4330
Etawa Do	4330 −	(360 + 1536)	= 2434
Cawnpore Do	2434 −	(800 + 308)	= 1326
Jumna Allahabad	1326 −	(1076 + 0)	= 250

leaving for the purposes of Navigation 250 cubic feet per second.

9. The dimensions of the main channel are represented in the following sections—

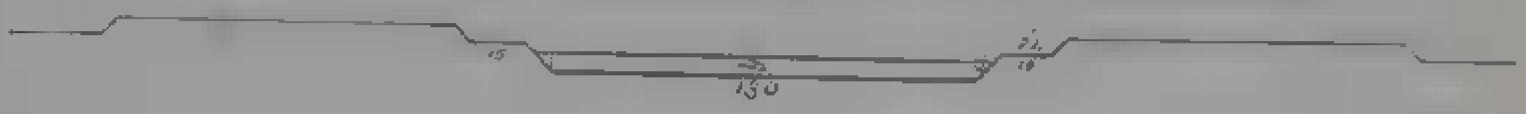
No. 1

From the Head of the Main Canal to the Futtehgurh Branch head distance 50 mile



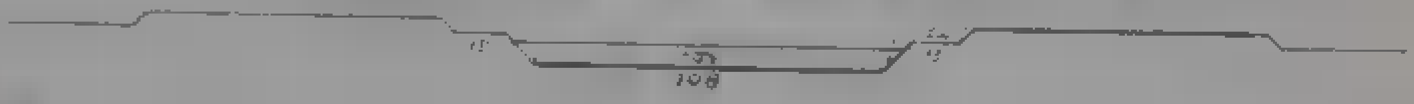
No. 2

From the Futtigurh Branch Head the Section will be reduced to:–



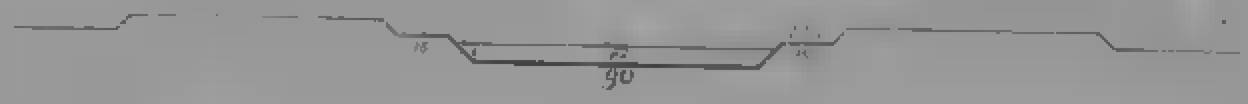
No. 3

From the Bolundshuhur Branch Head the Section will be reduced to



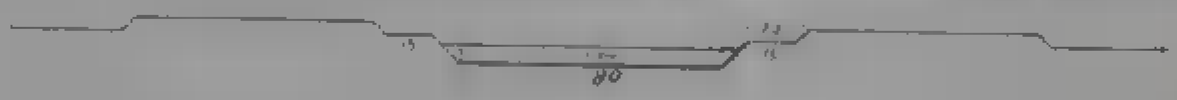
No. 4

From the Etawah Branch Head the Section will be reduced to



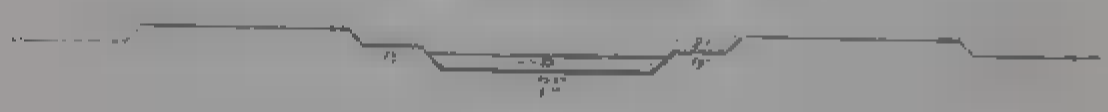
No. 5

From the Commencement of the 250th Mile the Section will be reduced to



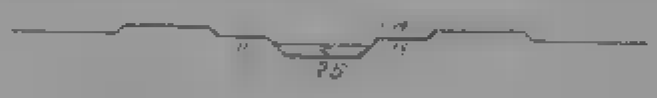
No. 6.

From the Commencement of the 281st Mile or from the Cawnpoor Branch the Section will be reduced to



No. 7

At the Terminus the Section will be reduced to



The capacities of these sections are as follows. The values of R and $\frac{1}{b}$ being calculated on no fractional parts beyond .5 in the former, and in round numbers in hundreds in the latter.

Section	Value of R	Value of $\frac{1}{b}$	Sectional area. Square feet	V in feet	Discharge	
					Theoretical	Required
No. 1	106.96	$\frac{1}{3520}$	1500	4.469	6703.5	6750
2	96.56	$\frac{1}{3520}$	1251	4.244	5309	5330
3	94.68	$\frac{1}{3520}$	1053	4.203	4425.7	4330
4	78.91	$\frac{1}{4224}$	731.25	3.474	2540.36	2434
5	72.24	$\frac{1}{4546}$	609	3.21	1954.89	1874
6	63.4[illegible]	$\frac{1}{5280}$	486	2.763	1341.36	1336
7	38.34	$\frac{1}{5280}$	116	2.109	244.644	250

The formula is thus, (Du Buat's)

$$V = \frac{306.55(\sqrt{R} - 0.10325)}{\sqrt{b} - \text{Hyp Log}\sqrt{b + 1.6}} - 0.31(\sqrt{R} - 0.10325)$$

where V = mean velocity per second.

R = Mean Radius, i.e. the area of the section in square inches, divided by the wall, or that part of the perimeter in contact with the fluid, in linear inches.

b = The denominator of the fraction expressing the slope of the bed, or surface of the water, the numerator being unity, so that a slope of one inch in one thousand is equal to $\frac{1}{1000} = \frac{1}{b}$ and $b = 1000$.

The ratio between the velocities at the surface, and those at the bottom, is exhibited in the following table, where v denotes the former and U the latter. The surface velocities have been

deduced from Dubuat's formulae; and the values of V and U of both Dubuat and Prony have been calculated

Section	Values, in feet of					Slope of Canal bed per mile in Inches
	v	V		U		
		Dubuat	Prony	Dubuat	Prony	
No. 1	5.13	4.46	4.15	3.79	3.18	18
2	4.88	4.24	3.95	3.60	3.02	18
3	4.83	4.2	3.91	3.37	2.99	18
4	4.04	3.47	3.27	2.90	2.50	15
5	3.77	3.21	3.05	2.65	2.33	14
6	3.31	2.76	2.64	2.25	2.02	12
7	2.53	2.1	2.06	1.65	1.58	[illegible]
	3.08	2.58	2.49	2.05	1.90	[illegible]
	3.20	2.69	2.59	2.18	1.98	12
	3.30	2.78	2.67	2.26	2.04	12

Dubuat

$v = (\sqrt{V} - .3 + .55)^2$

$V = (\sqrt{v} - .55)^2 + .3$

$U = 2V - v$

Prony

$v = \frac{V}{.81}$

$V = .81v$

$U = .62v$ } Assuming the rule quoted in the note*

With regard to the effect that the maximum velocity at the bottom, agreeably to the above table, may have upon the soil at the bed of the Canal, I am only able to draw inferences from what has occurred on the Doab Canal, where the disarrangement of the bed, depending not only on excess of slope, but on the irregularity with which that slope existed, was great; the points in the bed which suffered severely were those where the declivity per mile varied from 11 to [illegible]½ feet, or where, agreeably to the above formulae, the velocity of

* Prony having given no formula for the value of U, it has been calculated on Dubuat's rule $V = \frac{v + U}{2}$.

the current at the bottom was equal to 4.1 and 6.6 feet per second of Dubuat; and 3.39 and 5.25 feet per second of Prony. From 2 to 4 feet declivity per mile the action on the bed varied agreeably to the nature of the soil over which the current passed, but the action was not dangerous, though it must have been greatly influenced by the constant change of situation in the deposits of silt which took place at that period. In remodelling the slopes a maximum declivity of 2 feet per mile was determined on, which with the supply that the Canal might be expected to hold, would on the above formula give a velocity at the bottom equal to 3.5 a 3 feet per second. Up to the present period we have not had the means of testing the action on the remodelled slopes (from circumstances unconnected with these engineers the proposed slope of 24 inches was reduced to 23 inches per mile) with a mean radius of section greater than 40 f. this gives a velocity at the bottom equal to 2.7 and 2.3 feet per second, which might certainly be considerably exceeded, as far as I am able to judge from the stable state of the Canal bed; the soil is good.

It will be observed that in the project for the Ganges Canal the declivity of bed is less than that above alluded to, but the magnitude of the mean radius of the section gives a velocity to the current due to the greater slopes of the Doab Canal. I have no reason for anticipating any dangerous

effects from this velocity, but at the same time I would recommend, that the branches should not be commenced upon, until the main line is completed and the action of the water necessary for that line, carefully observed: a decrease in depth of water to the 1st section equal to [illegible] would reduce the current at the bottom of the Canal to 3.07 and 2.64 feet per second of Dubuat and Prony respectively, & would give a supply equal to 5490 cubic feet per second, which is somewhat more than is required for the purposes of both irrigation and navigation.

The following table is explanatory of the capabilities of the Stone Aqueduct, the depth of water being retained as in Section 1.

	area of Section in feet	R	$\frac{1}{b}$	Values in feet of					Discharge per second
				v	V		U		
					Dubuat	Prony	Dubuat	Prony	
Earthen Aqueduct Levels	1590	101.	$\frac{1}{3520}$	5.0	4.35	4.05	3.7	3.1	6916
Masonry Aqueduct	1700	97.1	$\frac{1}{3520}$	4.87	4.23	3.94	3.59	3.01	7191

Were each of the masonry channels reduced to a breadth of [illegible] the equilibrium between their total value and that of the Earthen Aqueduct, would be more perfectly established, but the stone piers which are fixed in the bed of the Channels at both extremities, may probably have some effect in interfering with the current, an evil which will be modified by this additional width.

The formula for Afflux (or rise to the water's surface level on the superior side, arising from the construction of a bridge over the course of a river) which has been used, is this—

$$\left(\frac{V^2}{2G} + p\right) \times (K^2 - 1)$$

V = mean velocity of current before the erection of the Bridge.

K = ratio between sectional area of the river & the aggregate waterway of the Bridge.

p = difference of level on embanked & narrowed part of the river.

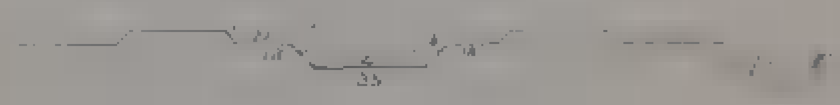
G = the acquired velocity at the end of one second by a gravitating or falling body, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] i.e.

11. The banks of the [illegible] in the space between the toe slope of the embankment and the channel are proposed to be raised 3 inches above the high water mark and the top of the embankments are not to be less than 4 feet above the same level. The receptacle or top of banks to be not less than 20 feet wide, except in the last 100 miles of the Canal where this minimum width may be reduced to 16 feet; where earth is in excess the extra soil will be used in extending the width to the rear; where there is a deficiency, the earth required for the completion of the banks to their full height and width will be obtained by digging superficial borrow pits not deeper than [illegible] inches either within the canal boundary, if without, the sides ought to be sloped off so as to admit of a plough passing over them. The limits to the

road ground ought to be marked off by a ditch 3 feet wide and as much deep.

[illegible] Branch

11. Forty three and a half miles long with a slope of 12 inches per mile — the supply to this branch is 308 feet per second. The masonry head at [illegible] from which the canal is supplied consists of two openings of 20 feet each. The capacity of channel at the point of departure is

Fig 19 

Section	Value of [illegible]	Value of [illegible]	Sectional Area Square feet	V in feet	Discharge. Theoretical	Discharge. Required
At the point of departure	56.81	5.00	246	2.334	6[illegible].66	308.

These dimensions decrease to a width of 21 feet until the branch terminates at the escape into the [illegible] at [illegible]. The capacity of this channel is sufficient for twice the quantity that the supply for irrigation demands, the excess of surplus water being thrown down it.

Space occupied by the Canal

12. It is proposed that plantations of forest trees should be [illegible] on each side of the canal, the berms, slopes and embankments being kept entirely free from all other trees or vegetation. Between, however, the [illegible] of bank and the proposed width of 20 feet, it will be desirable to keep a space not exceeding 30 feet in width clear for the purposes of a road way.

It will be evident on a reference to the table of excavation that beyond that required merely for the formation of embankments much superfluous earth will remain this waste is represented by the boundary ditch. On the early portion of the Canal the excavation is so extensive that the whole of the land within the boundaries will be raised to the height of the Towing path with the exception, however of the [illegible] slopes on the roadways. The [illegible] will be planted; the estimated area of land which the Canal will occupy on No 1 Project, may be estimated as follows.

Main Line

		Length Feet		Breadth Feet		Area	Total Acres
Division No	1	264000	×	600	=	158400000	
	2	316800	×	400	=	126720000	
	3	369600	×	300	=	110880000	
	4	369600	×	250	=	92400000	
	5	158400	×	200	=	31680000	
	6	913440	×	150	=	137016000	
				Total	...	657,096,000	
Then	$\frac{657096000}{43560}$						15084.84
Cawnpoor Branch		229680	×	150	=	34452000	790.90
Futtigurh Do		844800	×	200	=	168960000	3878.78
Bolundshuhur Do		369600	×	150	=	55440000	1272.27
Etawa Do		908160	×	200	=	181632000	4169.69
Total amount of Land required for the Main Canal and its Branches on Project No. 1							25196.48

13. In addition to the above, it is proposed to establish Orchards of grafted Mango trees at every 1st Class [illegible] [illegible] at every 15 miles or thereabouts – each Orchard to consist of 5 acres – these may hereafter be extended throughout the branch lines, but the main line only is now

taken into consideration. It will also be necessary to take in a portion of ground at Roorkee for the Work Shops, Timber Yard, Brick Ground and for general purposes. The additional space required under these heads may be estimated at 250 acres, viz

[illegible] lands & c.	190
Roorkee Ground	60
Total	250 acres

The object in combining with the plan for Plantations of Forest Trees, [illegible] for the greatest [illegible] manner to take advantage of the means of protection [illegible] offered by the Canal establishment [illegible] ground [illegible] in the whole line of the Canal [illegible] forest which in the natural state is highly prized by the native [illegible] and which cultivated under the [illegible] more [illegible] [illegible] formed out [illegible] the proceeds set off against the expenses of [illegible] outlay and maintenance [illegible] with the [illegible] of distribution [illegible] when the forest trees have arrived at maturity [illegible] it may be inferred that by the means proposed a very superior forest will be [illegible] disseminated.

[illegible] the above calculations the total area of land required for the purposes of the Ganges Canal and its branches, will be equal to 25196.48 acres, say 25200 acres, which at an average of 2 Rs. 8 annas per acre leads to an annual remission of Rs 63000. It may appear at first sight that this sum which is annually

disbursed from the treasury as long as the present [illegible] and [illegible] the equivalent of which is the land itself is struck out of the [illegible] when the next settlements take place, is not only [illegible] annual [illegible] to the Government but a dead weight upon the Canal [illegible] it must be recollected however, that the consequence of introducing facilities for navigation is an increased value of property and a security to the [illegible] of the Government revenue [illegible] and benefits to the State as exhibited in the Treasury Receipts, and that these [illegible] the [illegible] the [illegible] for land taken up [illegible] the Canal purposes appears [illegible] to be evident.

To [illegible] upon [illegible] the [illegible] for land occupied by the [illegible] the [illegible] of [illegible] standing crops [illegible] themselves [illegible] to determine the exact amount which may be carried to this account. It would be a necessary part of the superintendent [illegible] to make such arrangements as might prevent as much as possible, the [illegible] of standing crops [illegible] collected by foot [illegible] the [illegible] of the Canal at points where they existed, and giving warning to the cultivators not to sow within the limits of the Canal boundaries, when such boundaries had been [illegible] laid down, I am not [illegible] to estimate the

remuneration on this item at a high amount from uncertainty would have to be paid in what actually occurred. It should restrict the removal to that portion of the Canal limits occupied by the banks, berms and channel. In that portion within the boundary devoted to plantations, the trees standing might be allowed to remain as the property of the owner, until he wished to remove them, and the wells might continue in use for irrigation without in any way interfering with the interests of the Canal. This might be laid down as a general rule, the exception being where removal was necessary, in which case remuneration would be given.

The [illegible] remark [illegible] appended to Para 14 is equally applicable here; the expense will [illegible] or remission [illegible] either for lines, trees, houses, buildings, [illegible] with an ample return in the increased value of estates and property.

Ganges Canal Project No 2

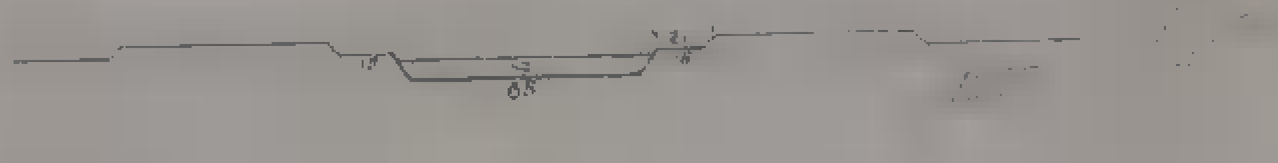
17. [illegible] to the 93[illegible] [illegible] with the exception of the Cawnpore Branch; there is no difference between this and the first Project, and Sec. 1 to 6 of the Sections with their calculated capacity for discharge remain as before. In this Project however the increased length of the Cawnpore Branch leads to a further removal of water from the main Channel of 172 cubic feet per second, which although for reasons before explained, no additional waterway is required at the head

of the Branch) renders a reduction to the section of the main line after the departure of that Branch convenient.

18. In continuation therefore from No. 5, section of Project No. 1 we have —

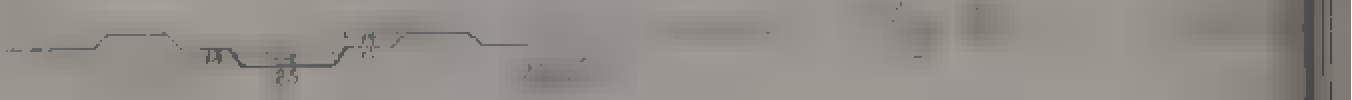
No. 6

From the Commencement of the 281st mile or below the departure of the Cawnpore Branch the section will be reduced to —



No. 7

From the commencement of the 361st mile the section will be reduced to — and continue to the terminus



Section	Value of R	Value of $\frac{1}{s}$	Sectional area square feet	V in feet	Discharge Theoretical	Discharge Required
No. 6	62.37	$\frac{1}{5280}$	426	2.696	1148.49	1194
7	28.34	$\frac{1}{5280}$	116	2.109	244.64	250

	Water demanded for Irrigation: Main Line	Branch	Discharge below Branch on the Main Canal
The expenditure on the Main Line to immediately south of the Cawnpore Branch	2434 — 800	+ 440 =	1194
To Allahabad	1194 — 944	+ 0 =	250

1194 cubic feet per second passes the 280th mile for the purposes of irrigation and navigation — the length of Canal being 173 miles — for the first

50, of which an allowance is made for irrigation agreeably to the 1st scheme of 0 cubic feet per mile, & to the latter from the reservoir for leakage 3.26 cubic feet per mile – the disposal of the whole head being thus:

For irrigation from the 230th to 260th mile		640 C.F.
	260th to 430 do	604 "
For Navigation		250 "
	Total Cubic Feet	1194

Stop Bridges will be placed on the Canal, south of the Cawnpore Road and south of the [illegible] Camp, to regulate the supply and protect the Canal on the reduced section commencing at the 260th mile from being overloaded.

49. It will be observed that, in the above calculation, the quantity of water in the Canal on its reaching the diminished section (Figure No. [illegible]) is equal to 644 cubic feet whereas the capacity of channel upon which the above section has been framed is only equal to carry 244.66 cubic feet per second – by referring however to the depths of excavation from the 260th mile downwards, [illegible], it will be seen that there [illegible] excess of feet, which as the minimum depth was that to be admitted into the calculations – the capacity of the channel therefore is fully equal to the quantity of water it will receive. I have been more willing to give an excess of water on this line, from the circumstance of the immediate neighbourhood of the Ghatampoor Pergunnah in the Cawnpore District, a tract of land lying to the south west of the

Town of Sank and the Fort of Meerut, and greatly in want of irrigation. The Pergunna in question, lies on the right or opposite bank of the Hindu River, but a Cut taken from the Canal at some point between Sukhinder and Ulawra, [illegible] of the [illegible] Doab would by the interposition of an aqueduct built over the Hindu, provide this tract of land with ample means for irrigation.

20. This project will add in a considerable degree to the amount required for remuneration on land [illegible] that for an additional length of 16½ miles to the Cawnpore Branch, thus

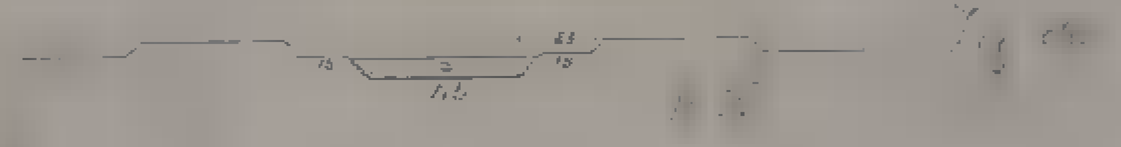
Miles		Feet		Feet		Sq. Feet		
16½	×	87120	×	150	=	13068000 / 43560	=	300 acres
		Brought forward						25196.5
		Total Acres required for No. 2 Project						25496.5

No. 3 Project.

21. Up to the departure of the Cawnpore Branch at the 250th mile the calculations remain the same as in the former Projects, from the point of separation each Branch, viz. that towards Allahabad, and that to Cawnpore, are projected as lines of navigation, the former being taken into the [illegible] south of the Hindu River, and the latter into the Ganges at Cawnpore. The sections are as follows.

No. 6

Allahabad Branch below Regulator at the point of Separation.



No. 7.

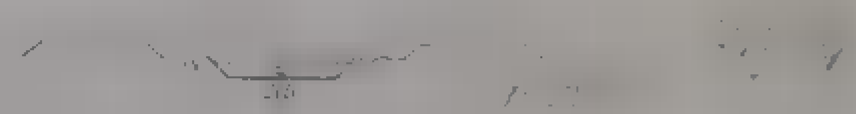
Allahabad Branch Terminus.

Section	Value of R	Value of $\frac{1}{S}$	Sectional Area Square feet	V in feet	Discharge Theoretical	Discharge Required
No. 6	64.45	5280	306	2.788	852.21	967.72
7	[illegible]	5280	116	2.109	244.64	250.

	Water demanded for irrigation Main line	Water demanded for irrigation Branch	Discharge below branch on the main line
Expected below in the main line immediately South of the Cawnpore Branch being	2434 − [illegible] + 425.25 + 250		= 967.72
To Allahabad	967.72 − 717.72 + 0		= 250

No. 6.

Cawnpore Branch below Regulator at the point of separation.



No. 7.

Cawnpore Branch at Terminus.

Section	Value of R	Value of $\frac{1}{S}$	Sectional Area sq. feet	V in feet	Discharge Theoretical	Discharge Required
No. 6	56.31	[illegible]	246	2.584	635.66	666.28
7	56.24	5280	116	2.109	244.64	250.

On the Allahabad Branch a reduction in width of one foot takes place in each 6 miles. On the Cawnpore one a similar reduction is made in every 6.

22. In this Project 1634 cubic feet per second reaches the point where the Allahabad and Cawnpore branches separate — out of which is required for the purposes of navigation 500 cubic feet per second, that is 250 for the terminus of each; the remainder, which is applicable to irrigation, is divided off as follows:

	cub. ft. per sec.	[illegible]
Allahabad branch 100 miles [illegible]	717.[illegible]	7.0871
Cawnpore [illegible] 163 – 6 – 55	416.280	7.07[illegible]

The proportion of water per second for the supply of each running mile is somewhat less than laid down in the 2d series of this Appendix.

23. The quantity of land occupied in this Project will be as before, deducting 93-20 miles as the difference between the length of [illegible] from the 160th mile to Allahabad and that from the 160th mile to the Jumna near the mouth of the [illegible]

viz:

Per former estimate [illegible] 264[illegible]6.4 acres

Deduct

$[illegible] + 150 - \frac{5707600}{43560}$ 1327.97

Total Quantity of land required for this Project 2416[illegible]5 acres

Sd. P. T. Cautley, Capt.

Director Ganges Canal

APPENDIX
G

Report [illegible]

[illegible]

Tube	[illegible]	[illegible]	[illegible]		Remarks
1	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	3	[illegible]	
3	[illegible]	[illegible]	2	[illegible]	
[illegible]	[illegible]	115	2	2	
[illegible]	[illegible]			3	
[illegible]	[illegible]	118	2		
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	3		
[illegible]	[illegible]	135	[illegible]		
11	[illegible]	[illegible]	2		
[illegible]	[illegible]	[illegible]	4		
[illegible]	[illegible]	[illegible]	[illegible]		
13	[illegible]	115	2	1	
[illegible]	[illegible]	[illegible]	3		
15	[illegible]	[illegible]	1		
16	[illegible]	[illegible]	3		
17	[illegible]	[illegible]	11	2	
18	[illegible]	[illegible]	3	3	
19	[illegible]	[illegible]	[illegible]	2	
20	1000	92	[illegible]	1	
21	1000	80	[illegible]	1	
22	1000	111	3		
23	1000	122	2		
24	1000	110	2	1	
25	1000	87	2	[illegible]	
26	1000	102	2	[illegible]	
27	1000	120	2		
28	1000	[illegible]		[illegible]	
29	[illegible]	101	3	[illegible]	
30	[illegible]	[illegible]	5	2	
31	[illegible]	[illegible]	3		
32	[illegible]	[illegible]	3	1	
33	[illegible]	100	2	1	
34	1000	110	2		
35	1000	[illegible]	2	[illegible]	
[illegible]	[illegible]	62	4	2	[illegible]
[illegible]	[illegible]	[illegible]	2		
38	[illegible]	63	2	4	
39	[illegible]	92	2	[illegible]	
[illegible]	[illegible]	80	3	2	
[illegible]	1000	83	3		
[illegible]	1000	[illegible]	3	[illegible]	
[illegible]	1000	131	2	2	
[illegible]	1000	111	3	4	
[illegible]	1000	108	3	6	
[illegible]	1000	75	[illegible]	5	
[illegible]	1000	137	2	3	
[illegible]	1000	101	2	4	
[illegible]	1000	[illegible]	3	7	
[illegible]	1000	55	5	2	
[illegible]	1000	[illegible]	4	1	
[illegible]	1000	[illegible]	5	2	
53	1000	112	3		
[illegible]	1000	94	3		
55	1000	105	2	4	
56	1001	63	3	5	
57	1000	76	4	2	
58	1000	71	4	1	
59	1000	61	5	1	
60	1000	30	2	0	
61	1000	132	2	1	
62	1000	75	3	1	
63	1000	85	2		
64	1000	73	2	3	
65	1000	50	11	4	

Distance	Wall		Central	
feet				
1000	191		9	[illegible]
1000	57		3	[illegible]
1000	60		[illegible]	[illegible]
1000	66		[illegible]	[illegible]
1000	79		2	[illegible]
1000	114		1	11
1000	57		[illegible]	[illegible]
1000	60		[illegible]	[illegible]
1000	71		[illegible]	[illegible]
1000	73		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	34		3	[illegible]
1000	65		1	1
1000	85		[illegible]	[illegible]
1000	113		[illegible]	[illegible]
1000	79		3	1
1000	87		[illegible]	[illegible]
1000	[illegible]		[illegible]	11
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	105		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	150		1	[illegible]
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	2
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	[illegible]
1000	137		1	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	1
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		10	[illegible]
1000	111		[illegible]	11
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		1	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	95		[illegible]	[illegible]
1000	[illegible]		[illegible]	1
1000	115		1	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	1
1000	115		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	47		[illegible]	[illegible]
1000	120		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	[illegible]		[illegible]	11
1000	[illegible]		[illegible]	1
1000	101		[illegible]	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	130		[illegible]	[illegible]
1000	97		[illegible]	1
1000	141		1	11
1000	[illegible]		[illegible]	[illegible]
1000	80		[illegible]	[illegible]
1000	85		[illegible]	[illegible]
1000	107		1	[illegible]
1000	[illegible]		[illegible]	[illegible]
1000	82		[illegible]	[illegible]
1000	104		[illegible]	1
1000	[illegible]		[illegible]	1
1000	90		1	10
1000	68		2	10
1000	85		1	15
1000	80		1	11
1000	77		3	1
1000	73		2	[illegible]
1000	83		1	9
1000	94		2	8

Remarks

[illegible]

[illegible]

[illegible]

[illegible] W. B. [illegible]
9th April [illegible]

APPENDIX H

Circular Memorandum [illegible]
on the [illegible] Canal.

Plan.

Dated [illegible] January 185[illegible].

Plan [illegible] Canal,
with [illegible] Plantations and
[illegible]

Fig. 1.

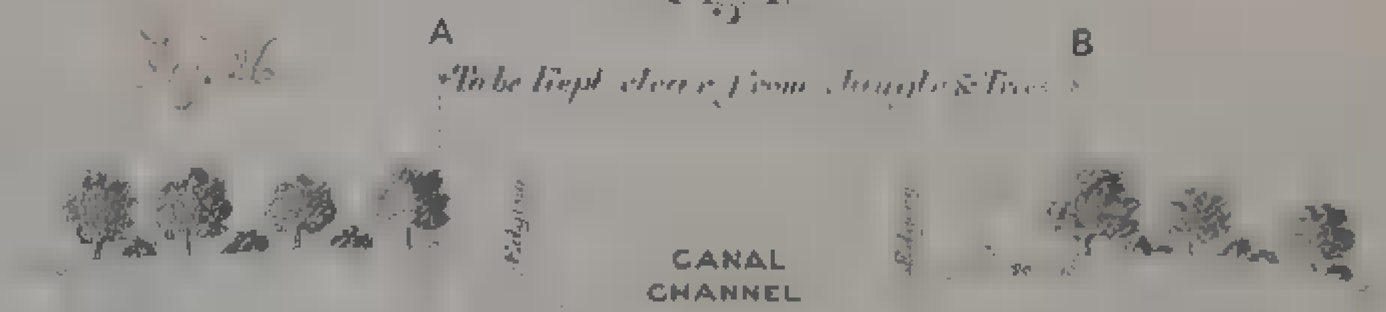


Fig. 2.

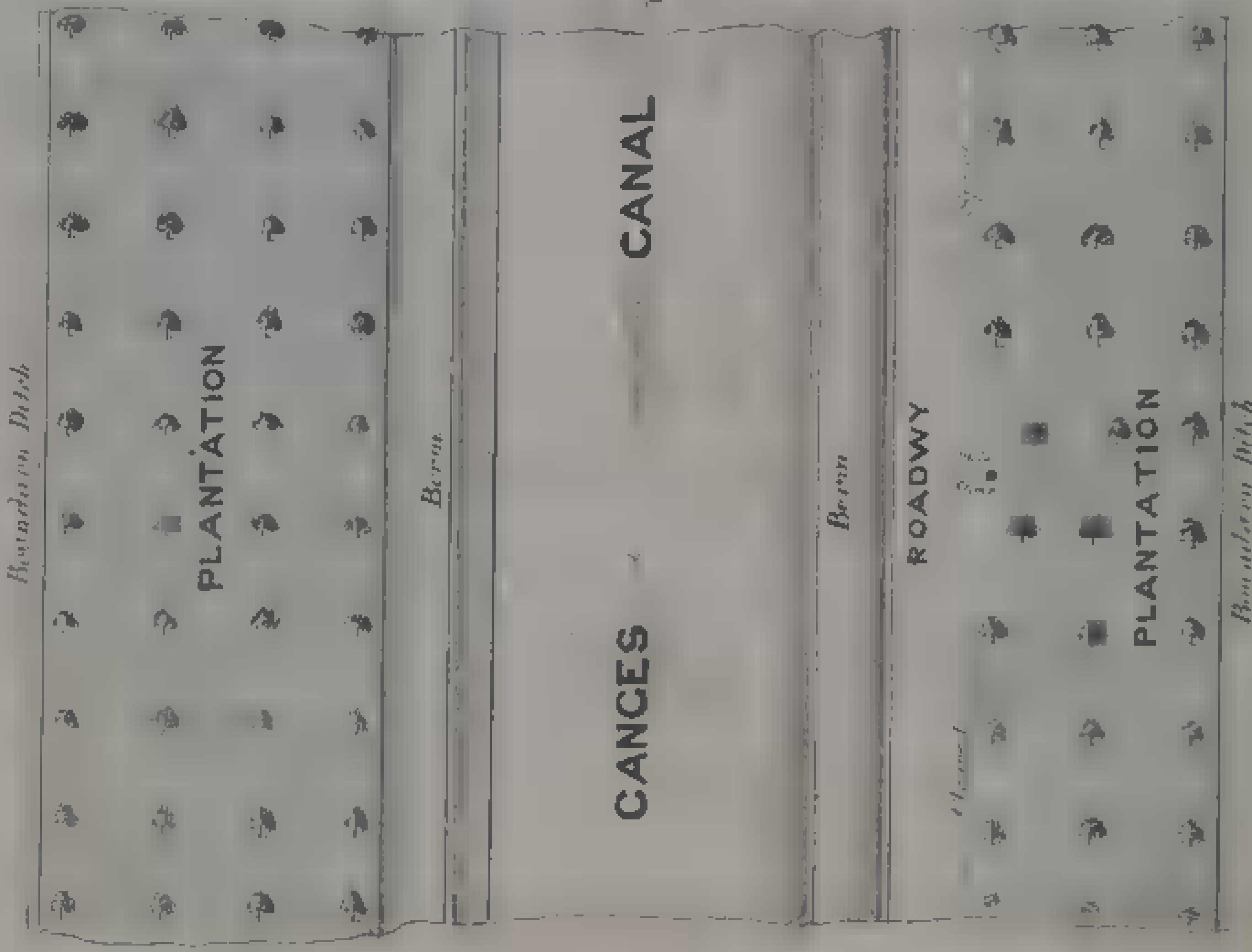


Fig. 3.

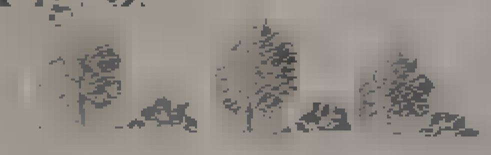


Fig: 1. Shows a Section of the Canal as it is supposed to be when the Plantations are

are established. These Plantations will, on the Right Bank of the Canal, be established from the boundary ditch to A, or to the foot of the interior Slope of the Embankment. On the Left Bank of the Canal the Plantations will be confined to the ground situated between the letter B and the Canal boundary on that side.

The intermediate space between A and B, including the interior Slopes, being Roadway and Canal Channel, will be kept perfectly free from Plantation, as well as from Jungle.

Fig: 2. Ground plan with a representation of the arrangement of Plantation and Roadway along Mile Stone; the Diagram speaks for itself. The Explanation for the Mile Stones will have [illegible] [illegible] depending on the width of artificial Esplanade [illegible]. The Mile Stones ought to be [illegible] detailed.

Fig 3. Shows the section of the Road on a larger Scale, with dimensions of Edging. It shows also the Slope to be given to the 20 feet Esplanade which is proposed to leave for the Roadway, and the [illegible] Space parallel to it; this slope is [illegible] upon the outside, so that the Canal Channel may not be made foul with [illegible]. [illegible] giving the slope is that the drainage may pass off to the outer boundary; any slope sufficient for this purpose will answer, whether it is 3 or 4 inches [illegible]. The Roadway itself will be maintained clean from Jungle or impediment of any sort, it will be kept [illegible] to a breadth of 20 feet, as shown in the Diagram; the 10 feet on the Canal which is intended to receive the dropping from the Trees and will relieve the Roadway from the

Projecting

projecting Branches, will be kept clear from Jungle, and it will act, in case of necessity, for Carts and Hackeries.

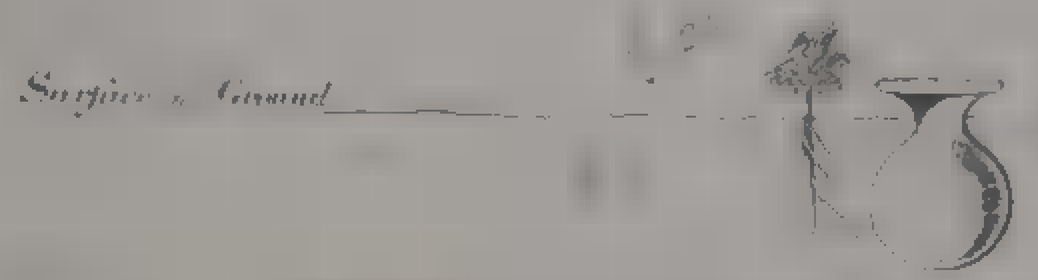
It is an object to keep the 20 feet Road free from Kunkur Metalling; but in very sandy tracts, like that in the upper parts of the Road and its branches, either Kunkur or clay must be laid down. I prefer the latter as more suitable for Horses feet and more agreeable for walking on. When Doob Grass is fairly established, the Earthen Road becomes very firm and good, as is shewn in the Road Banks of the [illegible] a stratum of 1 or 2 feet of good clay would answer every purpose I imagine.

The Embankment roadways are for domestic purposes only. they are not intended for traffic or for general public use. Strings of Carts or Cattle of any description are prohibited from coming upon the roadways, excepting in the train of a member of the Canal Establishment; the Establishment are specially called upon to use this line for Patrol and Inspection purposes.

The latter end of March and beginning of April is a favorable period for Tree planting; I take the opportunity therefore of pointing out that I am very desirous of establishing lines of Mango Trees (not grafts) along the Canal Banks. Trees of this sort require great care and more looking after than others and I wish to confine the Mango Tree-planting to two lines, one on the right the other on the left Bank. The position of the line on the left Bank is to be 20 feet in the rear

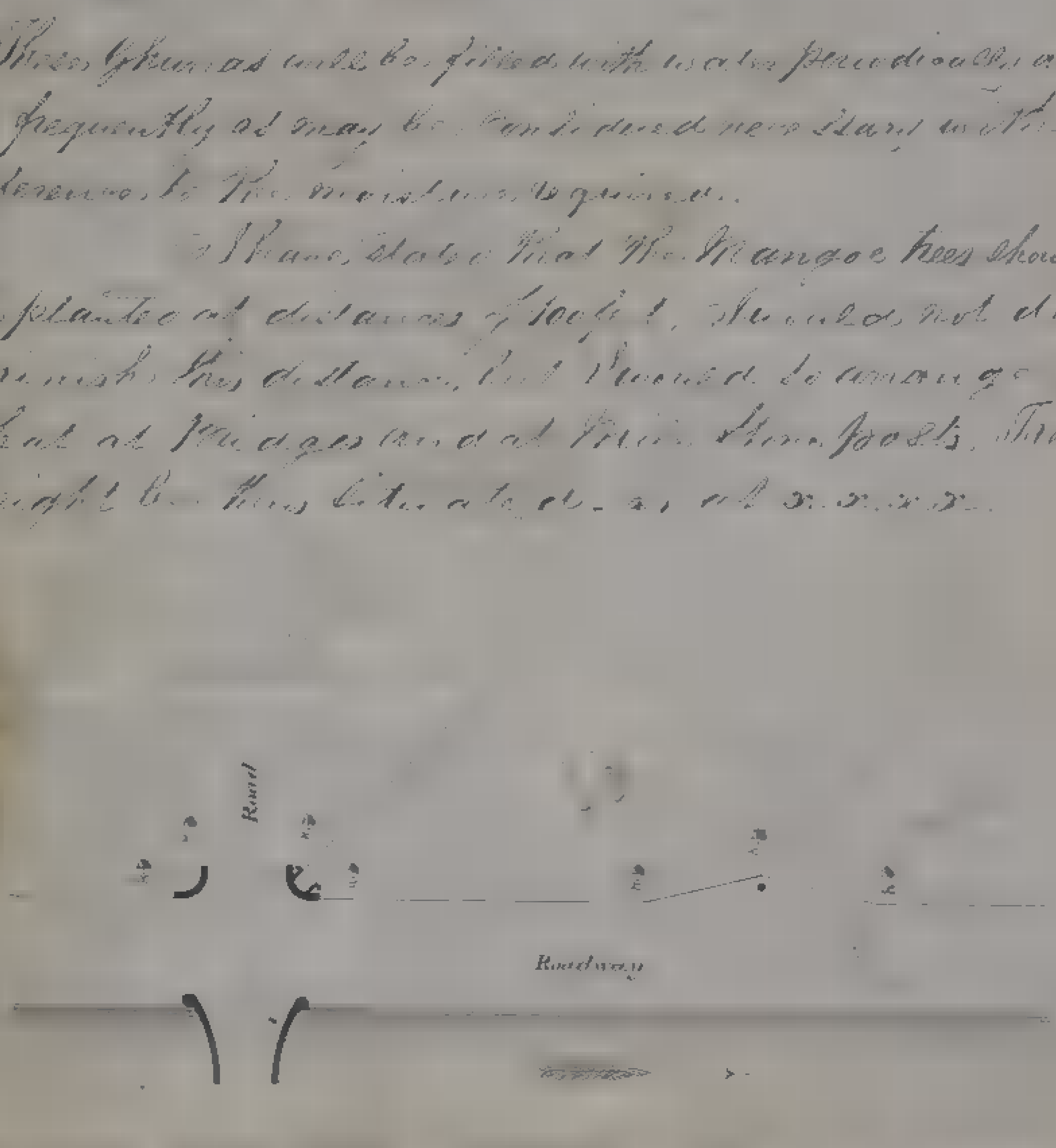
or on the left of the 30 feet passage for Roadway; that is to say, at a distance of 60 feet from the Crest of the interior Slope of the Embankment. The position on the right bank is to be exactly similar, viz: 60 feet to the right of the interior slope of the Embankments.

The Trees are to be planted at a distance of 100 feet from each other, so that about 52 plants will be required per mile. At the foot of each plant a Ghurra, or Kedgeree pot, in the bottom of which a very small hole is perforated, will be buried thus:



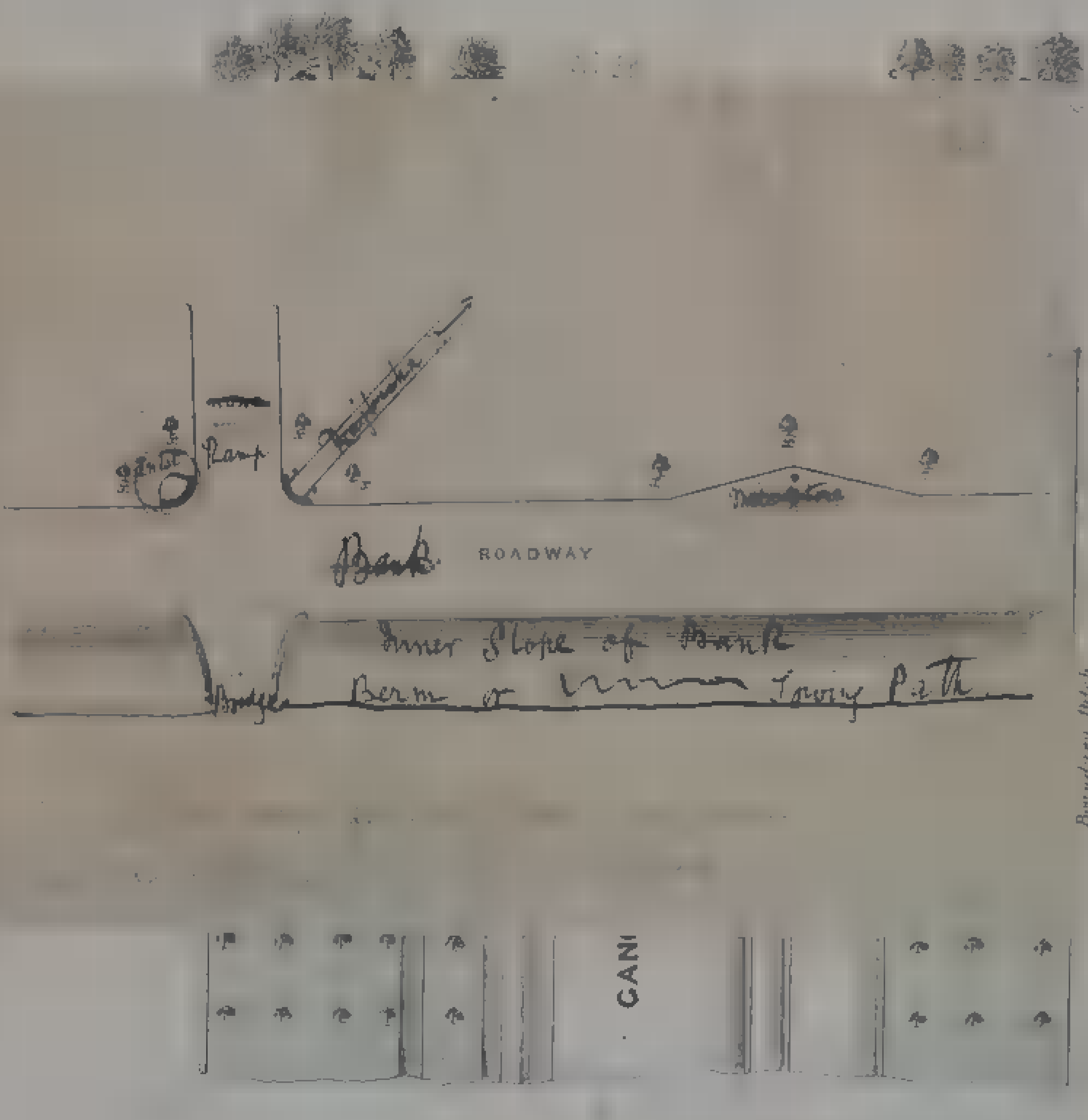
These Ghurras will be filled with water periodically and as frequently as may be considered necessary with reference to the moisture required.

I have stated that the Mangoe trees should be planted at distances of 100 feet. I would not diminish this distance, but I would so arrange that at Bridges and at Mile Stone posts, Trees might be thus situated, as at x. x. x. x.



I shall be glad to hear of the arrangement above described being entered on in the ensuing season.

The following Diagram will show the laying out which I propose for the Roadway and Plantations in those places where the Section of the Canal is thus:



The Roadway which is to be 20 feet wide, is to have a slight slope externally from A to B so that the drainage may be carried off at the foot of the slope BC to drains, as shown at x, which being situated at about 1000 feet apart, will drain the water into the boundary ditch of the

or on the left of the 30 feet passage for Roadway; that is to say, at a distance of 40 feet from the crest of the interior slope of the Embankment. The position on the right bank is to be exactly similar viz: 40 feet to the right of the interior slope of the Embankments.

The Trees are to be planted at a distance of 100 feet from each other, so that about 52 plants will be required per mile. At the foot of each plant a Ghuna, or Hedg

Sma

the

Mr Brunston
Doctor Cuman

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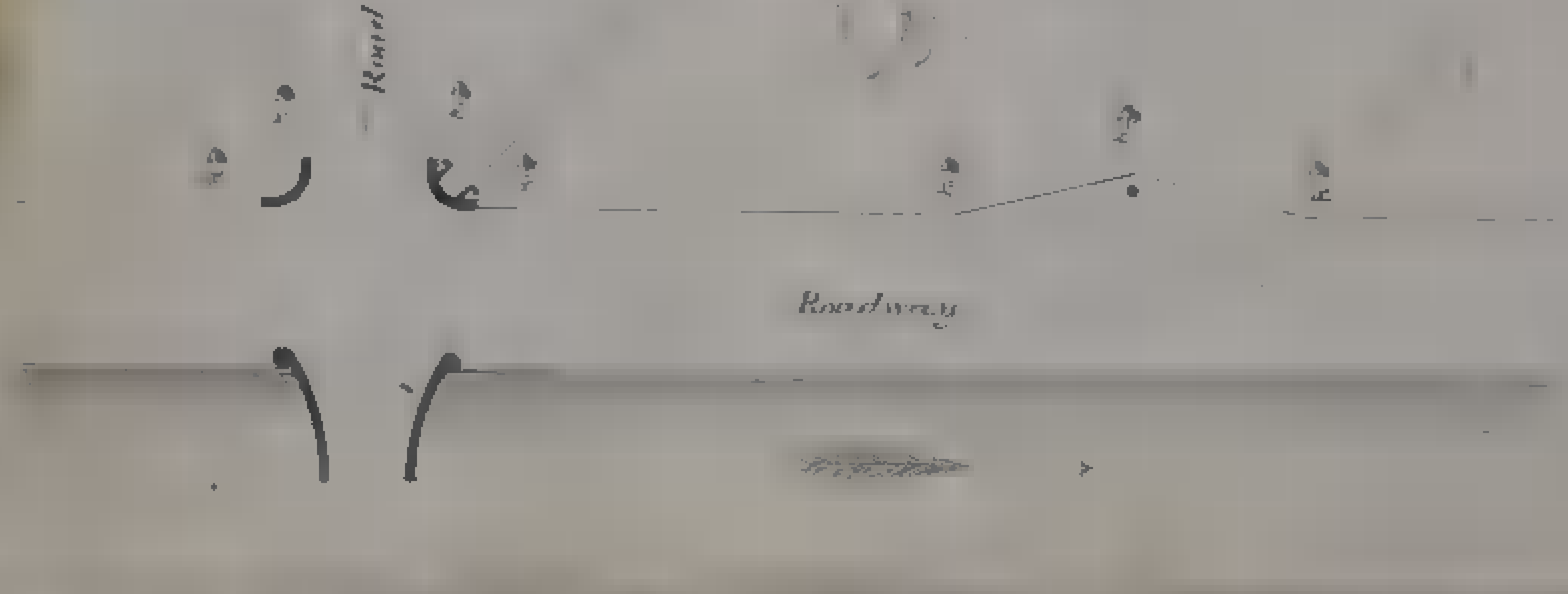
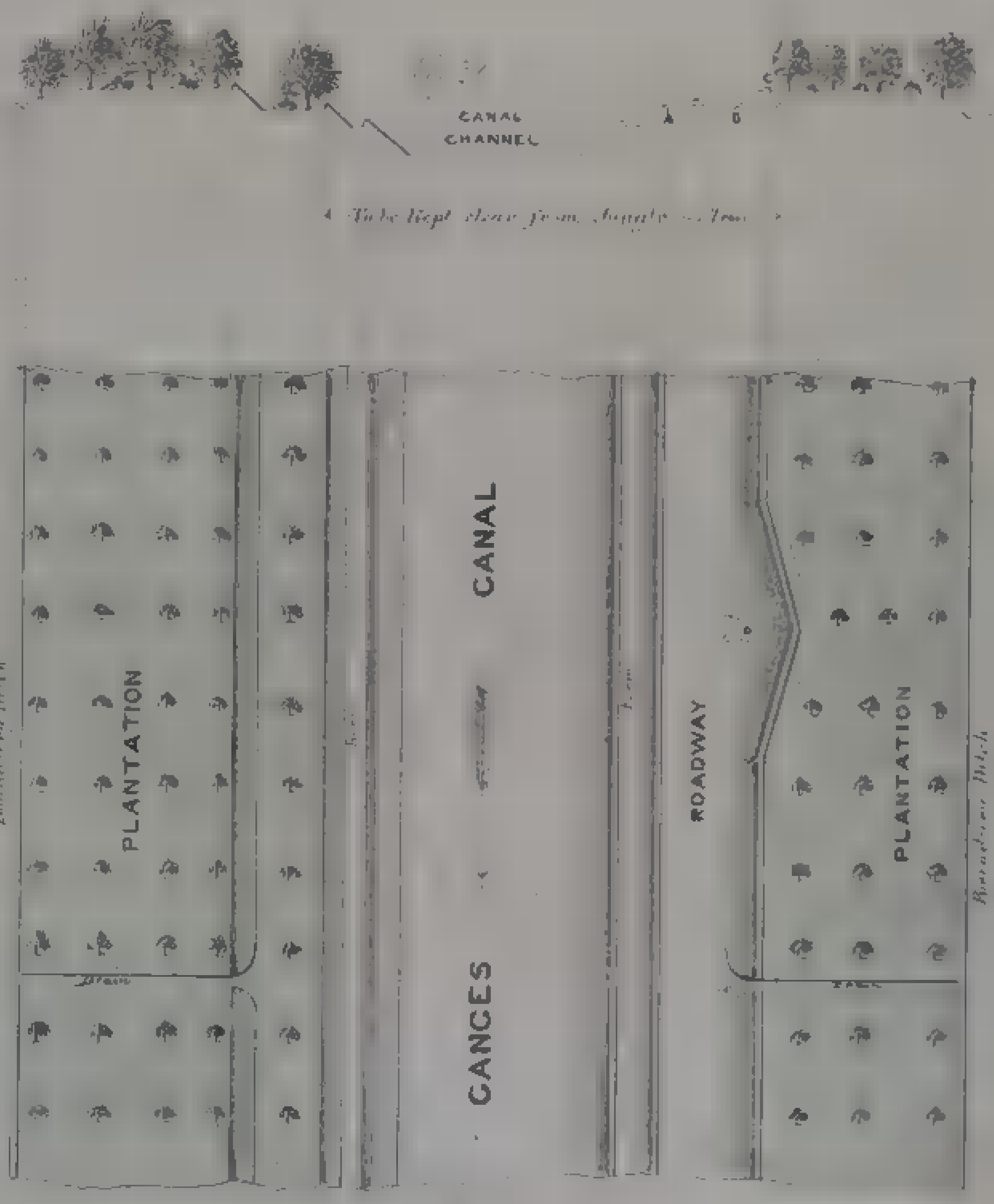
diminish the distance, but I would so arrange that at Bridges and at Mile Stone posts, Trees might be thus situated as at x.x.x.x.



I shall be glad to hear of the arrangements above described being entered on in the ensuing season.

The following Diagrams will shew the laying out which I proposed for the Roadway and Plantations in those places where the Section of the Canal is thus:



The Roadway which is to be 80 feet wide, is to have a slight slope laterally from A to B so that the drainage may be carried off at the foot of the slope BC to drains, as shown at x, which, being situated at about 1000 feet apart, will drain the water into the boundary ditches. I have

no

necessity, be given to heavy expenditure for bridges; where timber is at hand they can be protected from injury by very simple arrangements, [illegible] [illegible] or [illegible] [illegible] with [illegible] gravel; where there is no material but brick, the effect from this, a broken brick [illegible] [illegible] rather. The completion of bridges, may be [illegible] with great economy. But in many cases it is possible that no permanent [illegible] ought to be required at all. Engineers, however, will understand that [illegible] [illegible] to go to heavy expense [illegible] [illegible]. The drains will be [illegible] through the Plantation, and [illegible] [illegible], or [illegible] [illegible] of the following pattern.

Signed [illegible]

[illegible]

APPENDIX

I

Comparative Statement of Details requ[ired] … Canals.

Construction

Name of Builder	For how long and from what quarter	Description and Kind of Brick	Quality	Whether tested	Dimensions of Bricks	Quantity of Materials in cubic feet	Quantity of Materials	Bricks found	Total cost of laying	Laying performed in whose presence? Were the bricks fitted to their places? What extraordinary means used?	Precautionary … How far was work …
Mr. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	From 3/16 in. [illegible]	[illegible] feet	3,100 do.	49,000 L=12.01 B=5.73 D=2.04	1030. 6½	One arch laid in presence of Mr. W. May and [illegible] … carefully dressed … driven with wooden mallets	Earthwork … 36 feet … trenches …
[illegible]	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	[illegible] laid in presence of Mr. W. May and [illegible] … in presence of a … [illegible]	Do. do.
[illegible]	Do.	Do.	Do.	[illegible]	[illegible]	[illegible] feet	Do.	135,330. [illegible]	11182. 5	Laid in presence of Mr. Pogin … the laying was done … [illegible] … were hammered down …	[illegible]
[illegible]	Do.	Do.	Do.	[illegible]	[illegible]	3,850 do.	[illegible]	141,000	11,426.5	Partly in presence of Mr. [illegible] … partly in presence of [illegible] … the Mr. [illegible] Bridges.	[illegible] commenced
[illegible]	Do.	Do.	Do.	[illegible]	[illegible]	[illegible] do.	[illegible]	143,400	12,000	Partly [illegible] in presence of Captain [illegible] … [illegible] the bricks tightly filled in.	Earthwork [illegible]
[illegible]	Do.	Do.	Do.	[illegible]	[illegible]	[illegible] do.	[illegible]	85,178.	1301.6	Laying performed in presence of Mr. H. Pogin … [illegible] … being noted.	Earthwork [illegible]
[illegible]	Do.	[illegible]	[illegible]	[illegible]	[illegible]	3,991 do.	[illegible]	[illegible]	1317.3½	Laid in presence of H. O. [illegible] Madras [illegible] Engineers; the Bricks driven in with heavy [illegible] sledge hammers, a piece of [illegible] wood being interposed to prevent the Bricks [illegible] splitting.	Earthwork [illegible]

...truction of Arches of Bridges on the Ganges

1 | 2 | 8 | | | 10 | 8 | 7

...measures pre... ...ches. | Lowering and Removal of Centres, and its Results

...tion State of progress ... and ... ...ches at time of ... of Centering ... Arches.	After what interval of time after ... were Centres ...	[illegible]	[illegible]	Ultimate sinking of Crown of the Arches				Did any cracks appear? If so, what was their position & dimensions, their direction, whether parallel or otherwise perpendicular ...	[illegible]	Did any yielding of Abutments take place?
...ever 3 feet ... ... of ... Arches	12 hours	[illegible]	[illegible]	2¼"	3"	2¼"	2583 Lostr from Masonry	No cracks	[illegible]	None.
...	2 days	Do.	Do.	4"	5"	5¼"	[illegible] ... do do	Do.	Do.	Do.
[illegible]	[illegible]	[illegible]	[illegible]	.41"	.31"	3"	.78"	[illegible]	Do.	[illegible]
[illegible] ... 6 feet height.	12 hours	[illegible]		.37"	.25"	.20"	.57"	Do.	Do.	Do.
[illegible]	[illegible]	[illegible]		.23"	.21"	.25"	.25"	No.	No.	No.
[illegible]	[illegible]	[illegible]		4.6"	3.5"			[illegible]	No.	No.
... Arches ... feet below ... of Arches.	Lowered Simultaneously ... Keying	[illegible]		3.7"	3.7"	2.5"	3.5"	[illegible]	No.	No.

Bridge	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Remarks
Pabna [illegible]	Do. Bridge	[illegible]	[illegible]	1311 feet	2,139 do.	None	2 × 2 × 2	11,529 G	Keying performed in presence of Mr Conductor Cain and of Sergt O'Farrell and Super-intended by Lieut. Fraser at intervals. Method of Keying the same as at the Munglore Bridges.
[illegible]	Do.	[illegible]	[illegible]	1310 [illegible]	2,150 do.	[illegible]	11 × [illegible]	11,529 G	Keying of Eastern Arches performed by Mr Conductor Cain Ro[?] Fraser[?], and of the Western Arches in presence of Sergt O'Farrell by Lieut. Fraser [illegible] the general Keying was the same as the foregoing.
Berugdhoor[?]	Do.	[illegible]	[illegible]	.02	4030 feet	2,015 do. / 2322 do.	None	11,529 G	In the [illegible] of the [illegible] Keying as in Spring [illegible]
[illegible] a. Sig. V R 161 of I / Vol 2	Do.	[illegible]	Do.	0.25"	4030 feet	2,015 do.	None	11,529 G	In the [illegible] the Keying [illegible] driven in with hammers [illegible]
[illegible]	Do.	Do.	Do.	[illegible]	5465 [illegible]	1331	None	10,775	Do. Do. Do.
[illegible]	Do.	Well drawn	Do.	.23"	4400 feet	2200 do.	None	10,828	Do. Do. Do.
Sandut[?]	Do.	Do.	Do.	.22"	3619 [illegible]	2097 [illegible]	None	11,859	Do. Do. Well[?] [illegible] Do. Do.
[illegible]	Do.	3" Bricks drawn[?] [illegible]	Do.	[illegible]	3906 [illegible]	1953	None	11,714	Do. Do. [illegible] Do. do.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,980 [illegible]	1,786	None	[illegible]	[illegible] in presence of [illegible]
Jafiira[?]	[illegible]	3" Bricks drawn [illegible]	[illegible]	[illegible]	4,244 [illegible]	2122	None	10,415	In presence of Sergt [illegible] the Bricks as before
[illegible]	Do.	[illegible]	Do.	3/16"	1760 [illegible]	508	[illegible]	10,892	In presence of Sergt [illegible] Do. Do.

[illegible]	[illegible]	[illegible]	1.5"	0.8"	1.25	1.0"	No result.	No.	No.
[illegible]	Do.	Do.	15"	15"			[illegible]	[illegible]	Jones.
[illegible]	[illegible]	[illegible]	1.17	0.23	[illegible]	[illegible]	No.	No.	No.
[illegible]	[illegible]	[illegible]	3.01	3.06	[illegible]	3.2"	[illegible]	[illegible]	No.
Do.	Do.	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.	Do.
Do.	[illegible]	[illegible]	.06"	.04	.03"	.04	Do.	Do.	Do.
Do.	Do.	Do.	.03"	.05"	.07	.05	Do.	Do.	Do.
[illegible]	[illegible]	[illegible]					[illegible]	Do.	Do.
[illegible]	[illegible]	Do. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.	Do.	Do.
[illegible]	[illegible]	Do. / Do. [illegible]					[illegible]	Do.	Do.
[illegible]	[illegible]	Do. [illegible]	2¾"	2½"	3"	3⅛"	[illegible]	Do.	No.

[illegible]	[illegible]	[illegible]	[illegible]	Sandusky	Mer[illegible]	[illegible]	[illegible]	[illegible]	Juniata	[illegible] Hartford	[illegible]	[illegible]	[illegible]	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Do.	Do.	Do.	Do.	[illegible] required.	Do.	Do.	Do.	Do.	Do.	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	[illegible]	Do.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	24"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17[illegible]	4,222[illegible]	2,910[illegible]	3,701[illegible]	3,612[illegible]	31,000[illegible]	32,000[illegible]	2,930[illegible]	2,312[illegible]	2,087[illegible]	2,594[illegible]	2,164[illegible]	2,242[illegible]	3,100[illegible]	[illegible]
508	3,122	1,966	1,966	2,876	None	None	None	763	1,024	1,299	1,342	1,021	[illegible]	[illegible]
[illegible]	None	None	None	None	None	None	None	None	None	None	None	None	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Do.	38600.	31000.	73000.	73300.	77440.	77485.	77485.	60902.	18,722.	1,051,20.
1068[illegible]	10,415	10,7[illegible]	11,7[illegible]	11,852	12,474.	9300.	9300.	9750.72.	9803.38	7803.38	7803.38	8951.	1330[illegible]	1359[illegible]
In [illegible]	[illegible]	[illegible]	[illegible]	Do. Do. [illegible]	Do. Do.	Do.	In that of [illegible] Details [illegible]	Do. Do. [illegible]	Do. Do.	In that of [illegible]	Do. Do.	In that of [illegible]	Do.	In that of [illegible] Bahia.

[illegible]	[illegible]	[illegible]	18	15	15	13	No.	No.	No.
[illegible]	[illegible]	18 Do.	23	52	23	126	[illegible]		No.
[illegible]	2 months and 6 days.	In the same manner as above [illegible]	1.5	15	15	1.5	No.	No.	No.
[illegible]	15 Days. [illegible]	Do.	1/2	1/4	1/2	1 1/12	No.	No.	No.
Do.	2 Days. [illegible] in 15 days after.	Do.	1/2	1 1/4	3/4	1.3	No.	No.	No.
[illegible]	Immediately. [illegible] clean in 56 days.	Do.	1.5	1	1.5	1.3	No.	No.	No.
[illegible]	[illegible] 36 days after [illegible]	Do.	1.18	1.5	1.5	1.5	No.	No.	No.
[illegible]	1 month.	Do.	1.55	1.5	1.67	1.52	No.	No.	No.
Do.	20 days.	Do.	1.6	1.52	1.5	1.52	No.	No.	No.
Do.	2 months.	Do.	1.58	1.53	1.5	1.52	No.	No.	No.

	[illegible]	Yes.	Yes.	14 to 3"	3320 feet	[illegible]	[illegible]	[illegible]	[illegible]	In that of St. Mary's, Bricks driven in with wooden [illegible]	[illegible]
	Do.	Do.	Do.	14 to 22"	[illegible]	do	do	[illegible]	do	Do.	Do.
	Do.	Do.	Do.	[illegible] to 22"	[illegible]	do	do	[illegible]	do	Do.	Do.
	Do.	Do.	Do.	[illegible] to 22"	[illegible]	do	do	[illegible]	do	Do.	Do.
	Do.	Do.	Do.	[illegible]	[illegible]	do	do	[illegible]	[illegible]	In that of [illegible] [illegible] Repairs before.	Do [illegible]
	Do.	Do.	Do.	Do.	[illegible]	do	do	[illegible]	do	Do.	Do. Do [illegible]
	Do.	Do.	Do.	[illegible]	[illegible]	do	do	[illegible]	[illegible]	In that of [illegible] Repairs before.	Do. Do [illegible]
	Do.	Do.	Do.	22"	[illegible]	[illegible]	[illegible]	Do.	[illegible]	Do. Do. [illegible] Do. Do.	[illegible]
	Do.	3 bricks, [illegible]	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do. Do. [illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	3 bricks [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Repairs before.	[illegible]
	Do.	[illegible]	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Do. Do.	[illegible]

Do.	Nil Commenced.	17 [illegible]	[illegible]	.17	.17	.17	.17	[illegible]	Do.	Do.
Do.	Do.	Do.	Do.	.10	.15	.15	.13	Do.	Do.	Do.
Do.	Do.	Do.	Do.	.15	.10.5	.12	.13	Do.	Do.	Do.
Do.	Do.	Do.	Do.	.15	.13	.13	.14	Do.	Do.	Do.
[illegible]	[illegible]	[illegible]	Do.	.17	.2	.2	.17	[illegible]	Do.	Do.
Do.	Do.	Do.	Do.	.15	.12.5	.12.5	.13	Do.	Do.	Do.
Do.	[illegible] Commenced.	Do.	Do.	.12	.12	.15	.15	[illegible]	Do.	Do.

[illegible]	[illegible]	Do.	420.	13"	3111 [illegible]	[illegible]	[illegible]	67,825 / 12 × 6 × 3	10,000.	In that of a Mistress. Keyed as before.	Nature soil to spring of Arch.
Newmarket	Do.	4/23	420.	.016	1400 Maunds	do	do	60,560 do.	7510.	In that of St. Hume. Keyed as before.	Carried up to a height of [illegible] and the remainder [illegible]
[illegible]	Do.	Do	Do	.014	1100 Maunds	do	do	do	do	Do.	Do.
[illegible]	Do.	Do.	Do.	.016	1150 Maunds	do	do	do	do	Do.	Do.
[illegible]	Do.	Do.	Do.	do	1150 Maunds	do	do	do	do	Do.	Do.
[illegible]	Do.	Do.	Do.	.0155	1192 [illegible]	do	do	81,116 do	12,962	Do.	[illegible] of Arch [illegible]
[illegible]	Do.	Do.	Do.	.073	967 [illegible]	do	do	98,224 do	do	Do.	Do.
170	Do.	Do.	Do.	do	[illegible]	do	do	12,318 do	do	Do.	Do.
[illegible]	Do.	Do.	Do.	.032	12,16 [illegible]	do	do	44,000 do 800 [illegible]	6932	In that of M. Mensh. Do. Do. Do.	[illegible]
[illegible]	Do.	Do.	Do.	.24"	5612	20/6	[illegible]	Do.	1125	Do. Do. [illegible] Do. Do.	[illegible]
[illegible]	Do.	[illegible]	Do.	[illegible]	3,906	1963	[illegible]	[illegible]	[illegible]	Do. Do. [illegible] Cooper [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,5800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,122	[illegible]	[illegible]	[illegible]	[illegible] Keyed [illegible] as before.	[illegible]
[illegible]	Do.	[illegible]	Do.	3½"	17,6 [illegible]	308	[illegible]	[illegible]	[illegible]	[illegible] Do. Do.	[illegible]

[illegible]	Not examined	[illegible]	[illegible]	21	17	15	15	[illegible]	No	No
[illegible] Not Commenced.	2 days.	[illegible]	22	18	18	2	[illegible]	No	No	
Do.	Do. [illegible] up stream side [illegible] down stream side [illegible] do. do.	do	Do	1	1	15	116	Do	No	No
Do.	Same as at [illegible]	do	Do	22	22	22	22	Do.	No	No
Do.	Same as at [illegible]	do	Do	1	1	16	113	Do	No	No
[illegible]	[illegible]	Not noticing	Do.	16	16	22	17	No	No	No
Do.	[illegible]	Do	Do	16	[illegible]	15	[illegible]	No	No	No
Do.	Do.	Do	Do	16	[illegible]	15	15	[illegible]	[illegible]	No
Do.	Not Commenced.	[illegible]	[illegible]	2	2	2	2	No	No	No

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Dy in the Parent
bridge.

Mr. Cameron

	White Grain squeeze.								Dy in the Parent bridge.	Mr. Cameron
Do.	Do.	Do.	do.		do. do.	do.			Do.	Do.
Do.	Do.	Do.	do.		do. do.	do. do.			Do.	Do.
Do.	Do.	Do.	do		do do	do.			Do.	Do.
Do.	do	Do.	[illegible]		do. do.				[illegible]	
Do.	do	Do	[illegible]		do. do.				[illegible]	Do.
Do.	do	[illegible]	[illegible]		do. do.				Do.	Do.
Do.	do	[illegible]	[illegible]		do. do.				[illegible]	Do.
Do.	Do.	Do.	2½"				Do.		Do. Do. [illegible]	[illegible]
Do.	[illegible]	Do.	[illegible]						Do. Do. [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]
Do.	[illegible]	Do	3½"						[illegible]	[illegible]

Nil [illegible]	Right 33 hours, Arch [illegible], Centre 14, Left 22	As in the preceding.	1	1	2	135	No	No	No
Do	17 hours	do	35	23	2	[illegible]	No	No	No
Do	14 hours	do	2	3	3	2	No	No	No
Do	Do	do	3	2	3	23	No	No	No
[illegible]	3 days	[illegible]				[illegible]		No	No
	do	do				do 3/4" [illegible]		No	No
	do	do				do 8" [illegible]		[illegible]	No
[illegible]	do	do				do 3/4" [illegible]		No	No

[illegible]	[illegible]	[illegible]	[illegible]	Sandi[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Hunsoor[illegible]	[illegible]	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	do	do	do	do	do	do	do	do	[illegible]
[illegible]	[illegible]	[illegible]	3 Brick, [illegible]	Do.	do	do	do	do	do	do	do	do	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	do	do	do	do	do	[illegible]	[illegible] do.	yes	[illegible] do.
3/[illegible]"	[illegible]	[illegible]	[illegible]	2½"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]"	[illegible]"	3"
					[illegible]	[illegible]	1200 [illegible]	[illegible]	[illegible] 86 [illegible]	1500 [illegible]	9,250 to [illegible]	[illegible]	9,000 [illegible]
17[illegible]	4,2[illegible]	1,980[illegible]	370[illegible]	[illegible]									
308 [illegible]	[illegible]	1,766 [illegible]	1,963 [illegible]	20[illegible]									
[illegible]	None	None	None	None	37,[illegible] 12×6×2½	[illegible]	[illegible] 12×6×2½	[illegible]	33,136 12×6×2½	43,818 12×6×2½	12×6×2⅞ 44,000	[illegible] 12×6×2½	12×6×3 12×6×3½ 46,000
[illegible]	[illegible]	[illegible]	[illegible]	Do.	[illegible]	[illegible]	4,1[illegible] . 4	4,5[illegible] . 12	4,2[illegible]	[illegible]	5,068 . 12 . 5	5,0[illegible]	5546 . 12 . 5
[illegible]	[illegible]	[illegible]	[illegible]	1183 [illegible]									
In [illegible] Do.	[illegible] the Bricks as before.	[illegible]	Do Do [illegible] Pills do. do.	Do Do [illegible] Pillars Do. Do.	[illegible] before.	Ditto	Ditto	Ditto	Ditto	[illegible]	Under the [illegible] Bricks [illegible]	[illegible] simultaneously.	Under the Eye of Dr. [illegible] Bricks as before.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None.	Do.	Do.	Do.	Do.	None	Earth [illegible] arches. Not [illegible] watered.	None.	Earth [illegible] arches, but not [illegible] watered.

[illegible]		3 days	[illegible]				Not measurably [illegible]	Slight separation [illegible] at neither place.	No	No
done.	Wing wall, built.	do	do				do	No	No	No
[illegible]		do	do				do	Separation at each end [illegible] and construction at the joint [illegible] slight.	No	No
done.	Wing walls built.		do				do	A slight separation [illegible]	No	No
	do partly do		do	.03	.00	.02	.015	[illegible]	No	No
do	do		do	.025	.01	.02	.021	[illegible]	No	No
do	do height		do	.01	.00	.02	.01	None.	No	No
do	do		do	[illegible]	.01	.03	.07	[illegible]	No	No
[illegible]	Wing walls built	None,	do [illegible]	.02	.03	[illegible]	[illegible]	[illegible]	No	No

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
do	do	do	do	do	do	do	do	do	[illegible]
do	do	do	do	do	do	do	do	do	[illegible]
do	do	do	do	do	do	do	[illegible]	[illegible]	[illegible]
do	do	[illegible]	[illegible]	[illegible]	do	do	[illegible]	[illegible]	[illegible]
1896 c.f.	1224 c.f.	1800 c.f.	1830 c.f.	2297 c.f.	1432 c.f.	1700 c.f.	1175 c.f.	1175 c.f.	[illegible]
[illegible]	37,500	33,856	34,100	[illegible]	[illegible]	30,600	30,000	[illegible]	[illegible]
[illegible]	12"×6"×2 7/8	12"×6"×2 7/8	12×6×2 [illegible]	[illegible]	[illegible]	12"×6"×2 7/8	12"×6"×2 [illegible]	[illegible]	[illegible]
4338.0	4,010.7	4022.62	3947.85	4796.85	3605	[illegible]	[illegible]	4,016 [illegible]	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	Do.	Do.	Do.	Do.	[illegible]
do	do	do	do	do	do	do	do	do	[illegible]

[illegible]	[illegible]	12 hours	in the previous	.01	.01	.02	.02	[illegible]	1/10	1/10
do	[illegible]	Immediately	do 2 days	.02	.01	.01	.01	[illegible]	1/10	1/10
do	[illegible]	do	do	.03	.02	.01	.02	do	1/10	1/10
do	do	do	do	.03	.02	.02	.01	do	1/10	1/10
do	[illegible] walls [illegible]	do	do 2 days	.02	.02	.02	.02	[illegible]	[illegible]	1/10
do	do	do	do 3 days	.02	.02	.025	.02	[illegible]	1/10	1/10
do	do	do	do	.02	.02	.02	.02	do.	1/10	1/10
do	[illegible]	do	do	not accurately [illegible] ascertained				do.	1/10	1/10
do	do	do	do 6 days	.02	.02	.02	.02	do [illegible]	1/10	1/10
do	[illegible]	36 hours	do rapidly	Not ascertained				[illegible]	1/10	1/10

[illegible]	[illegible]	Margapen	[illegible]	[illegible]	[illegible]hundos	[illegible]	Kussudh	Sogaon
do	do	do	do 178	do	do	do	do	Same as before
do	do	do	do	do	do	do	do	[illegible]
do	do	do	do	do	do	do	do	Given in the [illegible] gas.
2/9	1/5	1/5	1/5	1/5	1/5	1/5	1/5	[illegible]
1150 c.f	1000 c.f	1100 c.f	1100 c.f	1200 c.f	1200 c.f	1444 c.f	1390 c.f	1422 c.f
22360 12"×6"×2 7/8 10"×5"×2 3/8	21,800 12"×6½"×2 7/8	23700 12"×6"×2 7/8	20560 12"×6"×2 5/8	24660 12"×6"×2 7/8	26030 12"×6"×2 3/4	27[illegible] 12"×6"×2[illegible] [illegible] 9×4½×2[illegible]	27786 12×6×2[illegible]	13989 12×6×2[illegible] [illegible]356 12×6×2[illegible]
2832	2759	2929½	2759	2681	3291½	3596½	3772	3772
Do	In presence of Asst Overseer as before.	Do	Do	Do	In presence of [illegible] as before.	Do	Do	Same as [illegible]
Do	Do	Do	Do	Do	Do	Do	Do	Not stated

Do. Do. Do. 24" … Do Do Asst Overseer Wilson Do Do. … Do Do Asst Overseer Mills as do. … In presence of Asst Overseer Mills as before. … In presence of Engl. Wilson Do Do.

No	[illegible]	[illegible]	[illegible]	[illegible]	Eight cracks [illegible]	None	None
Do	Wing walls, [illegible]	[illegible]	do	No	One crack [illegible]	do	do
Do	Wing walls, [illegible]	do	do	No	[illegible]	do	do
Do	do	12 [illegible]	do	No	[illegible]	do	do
Do	Wing walls [illegible]	do	do	No	[illegible]	do	do
Do	[illegible]	do	do		[illegible] do	do	do
Do	Do	do	do		[illegible] do	do	do
Do	Wing walls [illegible]	do	do	[illegible]	[illegible] do	do	do
Do	Do	do	do	[illegible]	[illegible]	do	do

Piave	Tessino	[illegible]	[illegible]	Santerno	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Muskegon	[illegible]
Do.	[illegible]	[illegible]	Do.	Do.	[illegible]								same as last
[illegible]	[illegible]	[illegible]	[illegible]	Do.	Do.								Yes
Do.	[illegible]	[illegible]	Do.	Do.	[illegible]								same as last
9½"	[illegible]	[illegible]	[illegible]	24"	[illegible]								[illegible]
17460	424003	238003	37060	36150									880 sq.
308	1122	1786	1963	2079	1000								2200
[illegible]	None	None	None	None	[illegible]								1740
[illegible]	[illegible]	[illegible]	[illegible]	Do.	2008								[illegible]
1099	10715	[illegible]	[illegible]	1165	In presence of [illegible] [illegible] as before.								In presence of [illegible] as before
In presence of [illegible] [illegible] Do. Do.	[illegible] as before.	[illegible] as before	[illegible] Do. Do.	Do. Do. [illegible] Do. Do.									

[illegible]	21 days	as before	[illegible]	Do	Do	Do

[illegible]

[illegible]	No	Yes	1/4	600	—	10000	2000	[illegible] Baxspor	Old Hale	
[illegible]	Do.	Do.	Do.	24"	5112	2845	[illegible]	Do.	1183	Do Do [illegible] 300.
[illegible]	Do.	3 Verch [illegible]	Do.	[illegible]	5706	1960	[illegible]	[illegible]	27741	Do Do [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2980	1786	[illegible]	[illegible]	16715	[illegible]
[illegible]	[illegible]	3 Verch [illegible]	[illegible]	[illegible]	4225	4122	[illegible]	[illegible]	10466	[illegible]
[illegible]	Do.	[illegible]	Do.	3½"	17600	508	[illegible]	[illegible]	10818	[illegible] Do. Do.

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do.	do.	do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
do.	do.	do.	[illegible]	[illegible]	[illegible]	[illegible]	Do.
do.	do.	do.	[illegible]	[illegible]	[illegible]	Do.	Do.
do.	do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None

Do.	Do.	Do.	22"	[illegible]	[illegible]	[illegible]	Do.	[illegible]
Do.	[illegible]	Do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Do.	[illegible]	Do.	3½"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Pumps	[illegible] Pumps	[illegible]		Do	Do	Do
[illegible]	[illegible]	[illegible]	.06 .06 .07 .002	[illegible]	Do	Do
Do	Do	Do	[illegible]	[illegible]	Do	Do
Do	Do	Do	.03 .04 .06 .002	Do	Do	Do
	12 [illegible]	No 12 ft Do	.03 .04 .06 .002	Do	Do	Do

do	[illegible]	[illegible]			13 × 6 × 3		
do	do	do			do	[illegible]	None
do	do	do			do	[illegible] as before	None
do							
do							
do	do	do			9 × 6 × 3 × 2 [illegible]	[illegible] and [illegible] as before	[illegible]
do	do	Yes	[illegible]		13 × 6 × 3	[illegible] as before	[illegible]
do							
do							
do	[illegible]	Yes	[illegible]		13 × 6 × 3	[illegible]	[illegible]

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Do.	Do.	Do.	24"	[illegible]	2847	None	Do.	1185	Do. Do. [illegible] Do. Do.	[illegible]
Do.	[illegible]	Do.	[illegible]	3706	1963	None	[illegible]	[illegible]	Do. Do. [illegible] Do. Do.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2980	1766	None	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4244	2122	None	[illegible]	10,415	[illegible] as before	[illegible]
Do.	[illegible]	Do.	3½"	1760	508	[illegible]	[illegible]	10,228	[illegible] Do. Do.	[illegible]

Do	[illegible]	As at [illegible]	Do	[illegible]	[illegible]	Do	Do
[illegible]	[illegible]	[illegible]	[illegible]			12 hrs	Closing 12 hrs after [illegible] and one [illegible] immediately
[illegible]	Immediately	As at [illegible]	[illegible]			Do	As at [illegible]
	[illegible]						2
	Do						
	Do						
	Do						

Wane	Akiona	Waimea	Hanalei	Kaulu				Wahiawa		Koolaupoko	Pemagum	Winter	Nanalaua	Kapaahulu
Do.	[illegible]	[illegible]	Do.	Do.				Do.						
[illegible]	[illegible]	[illegible]	[illegible]	Do.										
Do.	[illegible]	[illegible]	Do.	Do.										
[illegible]	[illegible]	[illegible]	[illegible]	22"										
1760	4,2400	2,980	3906	5,610										
588	2122	1776	1963	2807				10,000						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	Do.				1,8175						
1022	[illegible]	[illegible]	[illegible]	1183				[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]						

No	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX

J

Statement showing certain statistics connected with ...

1	2				3				4	5					
Name of Work	Distance of the Work from the Myapoor Regulator				Arches				Width of Roadway between Parapets	Measurement Content of Masonry	Materials Bricks				
	Miles	Furlongs	Yards	Feet	No.	Feet	Feet	Feet		Cubic Feet	12×6×3	12×6×2½	12×6×2	Smaller	
Head Works at Myapoor consisting of															
Dam ...										520101	–	36,4821	536		[illegible]
Revetment ...		.													
Ghats ...		.													
Myapoor Inlet		.			1	[illegible]	4	12	23						
Do ...		.			1	20	4	12							
Myapoor R. ...	0	0	0	0	10	20	4	12	37½						
Do 1st Class Choki	0	0	73	2											
Sounda ... Inlet	.	4	39	–	–	–	–	–	–	24694	–	62050			4656
Kunkhul Inlet ...	1	2	213							43673	–	81790			[illegible]
Kunkhul ...	–	–	–	–	–	–	–	–	–	–	–	–			
Kunkhul Bridge and Ghats	1	6	110	.	3	55	12	3	18	121683		320879	2155		[illegible]
Jowalapoor Inlet	3	1	185	.	–	–	–	–	–	48929	–	149750			7346
Jowalapoor Bridge "Dalhousie Ghats" and navigation Canal head	3	4	194	.	3	55	12	3	18	178961	–	734319	4975		[illegible]
Ranipoor ...	5	.	92	2	–	–	–	–	–	15917		146990			190

95690?	—	96991	—	[illegible] … the regulator … [illegible] … works and … [illegible] … in 18[illegible].	90659	2	7	Lieut. [illegible] Major [illegible]
4655	—	4565	—	[illegible] … water … [illegible] … the drainage … [illegible]	5628	2	8	Major [illegible]
8762?	—	8070	—	[illegible]	8271	14	9	[illegible] Major [illegible]
[illegible] ended	—	—	—	—	—	—	—	—
29878?	—	27734	—	[illegible] … the water … placed … the planks.	25503	6	5	[illegible]
9346	—	9622	—	Same as [illegible] but having a 100 feet [illegible] for clearing water.	8399	12	11	Major [illegible]
33276	—	35953	—	Bridge [illegible] foundations having [illegible] built by the Marquess of Dalhousie, of 100 feet in length [illegible] planks … [illegible]	39142?	9	11	Major [illegible]
795	—	780	—	Standard plan [illegible] feet square.	1895	12	7	[illegible]

Ranipoor Super passage and Works - viz No 1 Fall on main Canal Superstructure to form Super-passage over Fall and No 1 Lock to pass navigable and Irrigation Channel with Entrance Exit works	5	.	216	1	8 1 1	25 19 10	4 4 4	3 3 3	0	1636252	-	6213753	1500
Bahadoorabad Store Room No 1.	-	-	-	-	-	-	-	-	-	3968	-	3125	35300
Bahadoorabad Mills	-	-	-	-	-	-	-	-	-	-	-	-	Only
Bahadoorabad 1 Class Choki	6	7	163	2	-	-	-	-	-	11749	-	-	11933
Bahadoorabad Fall No 2.	6	7	163	2	8	25.5	2	28		424949	-	923500	728900
Bahadoorabad Lock No 2	do	do	do	do	-	-	-	-	-	83396	-	711043	-
Bahadoorabad Store Room No 2	-	-	-	-	-	-	-	-	-	3857	-	27596	-
Bahadoorabad Fall No 3	7	3	182	1	8	25.5	2	18		428291	-	1431220	-
Bahadoorabad Lock No 3 -	do	do	do	do	.	.	.	.		81065	.	289100	27000

14	-	300294	-	-	298395	-	These works consist of an Aqueduct 200 feet in breadth between its parapets for the passage of the [illegible] Torrent, the Canal passing under this 8 arches of 25 feet span each. On the up stream a Fall of 9 feet is projected to carry the canal to a lower level. On the left of the Falls is a Lock'd Channel passing boats under the [illegible] passage. The head of this Channel is situated at the [illegible] Bridge. On the left of the Lock Channel is another Channel for the [illegible] of the Balance [illegible] walls. The Channels of entrance and exit have their sides revetted with masonry on a considerable length.	352088	2	8	Major Goodwyn
	-	186	-	-	89	-	[illegible]	511	13	7	Major Goodwyn
[illegible]			-	-	-	-	-	-	-		-
	-	490	-	-	2[illegible]1		Same as [illegible]	1786	3	[illegible]	Major Goodwyn
11,919 Thana		75310	-	-	71418		This fall is 9' drop [illegible] in breadth of the Bridge which is [illegible] the head of the fall	72788	8	11	Do
	-	13954	-		16340		Has a drop of 9 feet [illegible] Lock Channel [illegible]	15807	3	2	Major Goodwyn
	-	147	-	-	92	-	Same as No 1.	[illegible]		[illegible]	[illegible]
7940 Thana		75993	-	-	77670	-	Same as No 2 Falls but having its wing walls curved to suit a change in the direction of the Canal alignment	67613	10	3	Do
	-	15302	-		14391	-	Same as No 2 -	14701	5	2	Do

Tulempoor Inlet	8	1	163	2	-	-	-	-	-	35253	-	109413	-
Puttri 1st Class Choki	9	4	161	-	-	-	-	-	.	14133	.	127608	-
Puttri Supr passage and works viz. Full in Main Canal Lock in Navigable Canal Supr structure to form Supr-passage over Fall and Lock with Entrance works -	9	5	210	..	9	25	4	3	300	2243591	-	9411011	-
Kudsraj poor Inlet	11	6	71		-	-	-	-	-	23763	-	75974	-
Dnunowri 1 Class Choki	12	6	61		-	-	-	-		10190		101400	-
Rutmo dWorks viz: Roadway Bridge / Inlet and Scuttle Dams / Regulating with Works / Arrangements connecting the whole together	12 / 12 / 13	6 / 7 / ..	73 / 23 / 109	. / 1 / 1						1496463		12134613	-
Peeran Kulleeun Bridge	14	2	133	2	3	55	737	3	18	145214	-	756800	-

–	6836	–	–	7148	–	Same as the Lowndes [illegible] works, but having a passage for [illegible] drainage of 15 feet –	9193	2	2	Major Goodwyn
	704	–	–	577	–	Standard plan, the foundations being built on a series of arches –	1759	2	2	Major Goodwyn
[illegible]	285737	–	–	403945	30479	Same as the [illegible] works but the Aqueduct has a waterway of 300 feet at the [illegible] [illegible] Navigable Channel [illegible] the Main Canal [illegible] Falls [illegible]	237321	12	1	Do.
–	3928			3967	[illegible]	Similar to the Lowndes [illegible] works but [illegible] consequence of the [illegible]	8283	13	8	Do.
	374			576	–	Standard plan	[illegible]	12	4	Do.
[illegible]	208981	–	–	397906	6038	On the approach to the [illegible] Canal [illegible] [illegible] the 251 [illegible] drainage of [illegible] feet [illegible] additional [illegible] Bridges, the [illegible]	522231	2	1	Do.
–	1742	–	–	34892	–	This Bridge differs from the ordinary ones in having its Arches segmental instead of Elliptical – and in the height of Roadway being 36½ feet in the Flooring of the [illegible] instead of the Pathways or the Towing Paths as proposed in the abutments [illegible] [illegible] to the same height as the [illegible] with which they correspond –	35307	14	..	Major Goodwyn

Solani Aqueducts Works consisting of													
Mahewur Bridge	15	7	150	.	3	55	12	3	18				
Aqueduct Proper	18	"	134	2	15	50	3	5	—				
Roorkee Bridge	18	5	169	1	3	55	13	3	18				
Earthen Aqueduct with Masonry Revetted sides connecting the whole of the above works together. above the Mahewur Bridge are Ogee and Cattle Ghats with Escapes. Below the Roorkee Bridge there are similar Ogee & Cattle Ghats with a Revetment protecting the right bank on the whole length of the Roorkee Curve –										107,54,218	15080	82764338	3887809
Roorkee Workshops	-	-	-	-	-	-	-	-	-	571329 not complete	–	3132057	–
174													
Director's Office	-	-	-	-	-	-	-	-	-	11223	–	[illegible]	–
Visitors' accommodation Bungalow	-	-	-	-	-	-	-	-	-	22059 27	–	157977	–
Hospital	-	-	-	-	-	-	-	-	-	[illegible]			[illegible]
Mr Parker's Bungalow	-	-	-	-	-	-	-	-	-		–	20000	–
Burial ground	-	-	-	-	-	-	-	-	-	5615		48280	–
Guneshpoor Bridge	20	.	21.	2	3	55	12	3	18	78327 not complete	–	112600	–
Dhoofnuggur 1st Class Choke	22	4	216	2	-	-	-	-	-	12088	–	–	12000

587005 Thomas Thurnham	176588	-	-	2412802		The commencement of these works are Escapes on the Right Side of the Canal which if required can be used as safety valves - these Escapes are followed by Cattle Ghats for the approach of Cattle to the Canal water. From these Ghats the Revetments of the Earthen Aqueduct commence they meet the Mahewar Bridge in Ogee Curves and leave it similarly they are then carried in a direct line till they approach the Aqueduct. Here the Canal passes thro' the Aqueduct [illegible] in 2 Channels, and the Torrent passes under the Canal in 15 arches of 50 feet Span each. Below the Aqueduct Bridge and above and below the [illegible] Bridge the Revetments Head corresponds in all respects with those on the [illegible] side except that there are no escapes. The right bank of the Canal below the Aqueduct [illegible] is revetted on the [illegible] length of the Curve where the Canal takes at that point	3286,812 10 9	[illegible] Cautley [illegible] and Major Goodwyn	
2459 Thomas	40136	-	-	44218	-	These buildings contain separate accommodation for [illegible] [illegible] [illegible] [illegible] [illegible]	8545 . .	[illegible] Major [illegible]	
	2152	-	-	189[illegible]	-	[illegible]	336[illegible] 14 5	Major Goodwyn	
Do Thomas	1336	-	-	550	-	[illegible]	3441 7 10	Do	
-	—	—	—	—	—	a plain room with [illegible]	1286 1 7	Cautley	
-	120	-	-	120	-	—— ——	1008 10 6	Major Goodwyn	
-	582	-	-	692	-	merely a plain wall	735 5 11	Do	
15520 Thomas	10489	-	-	21744	1884	Same as Kunkhul but with a different form of [illegible]	17738 8 6	Major Goodwyn and Lt Fraser	
.	663	-	-	882	-	Standard Plan	2357 10 4	Major Goodwyn	

Assofnuggur Ganga old Channel Head works and Right Rajbaha Head				-	-	-	-	-	68975	-	73050	-
Assofnuggur Falls	22	5	196	2	8	25 55	2	18	421913	-	3467766	-
Assofnuggur Locks Mills and Left Rajbaha Head	do	do	do	do	3	[illegible]		15	[illegible]	-	430967	-
Munglour 2nd Class Choki	24	5	194	-	-	-	-	-	4577	"	34327	
Munglour Bridge and Ghats on both up and down stream	24	6	94	2	3	55 12	3	18	126096	"	945720	
Puhaneri 2nd Class Choki	26	1	80	-	-	-	-	-	2576	19320	-	-
Puhaneri Bridge and Ghats	26	1	189	1	3	55 12	3	18	139954	"	1049655	
Mundowli Bridge	28	5	124	.	3	55	[illegible]	21	59542	"	446565	
Mymoodpoor navigable head and Right Rajbaha head	30	3	100	-	-	-	-	-	56997	"	427477	
Mymoodpoor 1st Class Choki	30	7	182	2	-	-	-	-	14316	"	107370	
Mymoodpoor Locks Mills and Left Rajbaha head	31	-	97	1	3	(20 to 24)		15	127044	"	952830	
Mymoodpoor Falls	31	-	144	2	8	25 55	2	18	451597	"	3386977	
Dimas Bridge with Ghats	33	5	93	1	3	55 12	3	18	135719	"	1017,893	
Jognidpoor 2nd Class Choki	38	-	57	-	-	-	-	-	2488	"	13215	

13625 Than	13223	—	—	20140	—	Two [illegible] Block of Masonry built into the bank of the Canal at the point of bifurcation of the channel and forming the left [illegible] of the main Canal & the other the right of the [illegible] one. Opposite these [illegible] of these [illegible] the [illegible] [illegible] is in [illegible]	17525	14	2	Major Goodwyn & Lt Fraser
						[illegible]				
6250 Than	65860	—	—	85735	—	Similar to the No 2 Bahadurabad Falls except in dimensions which are greatly increased to suit the extra [illegible] that is here met with —	9419	—	6	Major Goodwyn
2900 Than	6800	—	—	10362	504	[illegible] appendix	not complete			Major Goodwyn and Lt Fraser
—	763	—	—	1525	—	A 1 Room'd House 20'×20' with a door [illegible]	757	9	11	Mr F Read —
	21016	—	—	42032	—	Foundations 12' to 13'.3" below Canal bed. Ghats of 24 feet length on each flank the whole being protected by [illegible] and [illegible]. Towing Path [illegible] wooden frame work —	24131	3	..	Lt Turnbull and Lt Fraser of the Engineers and Mr F Read —
—	429	—	—	858	—	One Room 18'×14' [illegible]	304	10	10	Lt Turnbull
—	23326	—	—	46651	—	Foundations 11'6⅞" below Canal bed. 24 feet Ghats on down stream. Protection as at [illegible]	23577	4	8½	Lt Fraser and Mr F Read
—	9924	—	—	19847	—	will be the same as the [illegible] Bridge but without Ghats. Foundations 15 feet below Canal bed —	12897	11	11	Mr Read
—	9500	—	—	19098	—	Similar and [illegible] the same objects [illegible] the same kind of works at Assofnugger —	10996	15	1	Mr Read
—	2386	—	—	4772	—	Same as at Assofnugger	2422	14	6	Mr Read
—	21174	—	—	42348	—	Same as at Assofnugger	23960	14	9	Mr F Read
—	75266	—	—	150532	—	Same as at Assofnugger	80496	5	8½	Lieut Fraser and Mr Read
—	22620	—	—	45239	—	Same as at [illegible] Foundations 15 feet [illegible] —	25715	7	10	Do
—	294	—	—	587	—	Same as at [illegible]	276	[illegible]	[illegible]	Mr F Read —

Jogmulpoor Bridge	38	.	149	1	3	55	12	3	18	112690	845175		–
Baira Navigable Channel Head and Right Rajbuha	41	6	138	2	1	10	5	2	.	57104	428730	–	–
Baira 2nd Class Choki	42	3	80	1	.	.	.	.	.	3068	23010	–	–
Baira Locks, Mills and Left Rajbuha Head	42	3	138	.	3 (2 of 10, 1 of 15)				15	126675	950062	–	–
Baira Falls	42	3	185	1	8	25	55	2	18	396370	– "	2972775	
Baira 1st Class Choki	44	.	153	.	.	.	.	.	.	10225	76687	–	–
Baira Bridge	44	1	41	1	3	55	12	3	18	112931	846982	–	–
Bhopah 2nd Class Choki	46	3	177	2	.	.	.	.	.	2404	18030	–	–
Bhopa Bridge	46	4	44	.	3	55	12	3	18	109543	821572	–	–
Sowli Navigable Channel Head & Right Rajbuha	47	4	204	.	1	10	5	2	–	45575	341812	–	–
Sowli Falls	48	2	11	2	8	25	55	2	18	367130	2753475	–	–
Sowli Locks, Mills and Left Rajbuha Head	48	2	26	.	3 (2 of 10, 1 of 15)				15	131506	986295	–	–
Futtigurh Branch Head Regulating Bridge	50	2	205	2	4	20	6	1.5	18	136046 (for the 3 items)	1020345	–	–
Ghats & Platforms connecting above with	50	3	48	.	.	.	.	.	–				
Sowli Main Canal Regulating Bridge	50	3	81	.	9	20	6	1.5	18				
Sowli 1st Class Choki	50	4	22	.	.	.	.	.	.	13998	–	104986	–
Dukheri 2nd Class Choki	53	2	102	2	.	.	.	.	.	2928		21960	–
Dukheri Bridge	53	3	16	.	3	55	10	2¾	18	91199	– "	683992	
Jansut 2nd Class Choki	54	4	195	.	.	.	.	.	–	2928	21960	–	–
Jansut Bridge and Ghats	54	5	108	2	3	55	10	2¾	20	146655	– "	1099912	
Chitowra Navigable Channel Head & Right Rajbuha Head	55	1	182	1	1	10	5	2	–	56161	do	421207	
Chitowra 1st Class Choki	55	6	134	2	.	.	.	.	–	15547	do	116602	
Chitowra Locks, Mills & Left Rajbuha Head	55	6	182	.	3 (2 of 10, 1 of 15)				15	141537	do	1061527	

–	16782	–	–	37563	–	Same as Mungapur [illegible] but without [illegible]. Foundations from 11.3 to 16' deep	22716	8	5	Lieuts Turnbull & Fraser & Mr Read.
–	–	–	19054	9528	–	Same as at Tagmoodpur	10601	13	10	Mr F Read.
–	–	–	1023	511	–	Same as at [illegible]	275	14	2	Lt Turnbull
–	–	–	42225	21112	–	Same as Tagmoodpur	18109	14	10	Mr F Read
–	–	–	132123	66062	–	Same as at Tagmoodpur except that [illegible] [illegible]	77523	3	9	Lt Fraser & Mr Read
–	–	–	3408	1704	–	Standard plan	1184	9	11	Lt Turnbull & Fraser
–	–	–	37643	18822	–	Same as Jaghatpur Foundations 15½' deep	21662	11	3	Lt Turnbull & Fraser and Mr Read.
–	–	–	802	401	–	Same as [illegible]	235	10	6	Lt Turnbull & Fraser.
–	–	–	36514	18257	–	Same as Jaghatpur Foundations 15' deep	21760	12	3	Lt Fraser and Mr Read.
–	–	–	15191	7695	–	Same as Tagmoodpur	8964	3	3	Mr F Read
–	–	–	122377	61188	–	Do	61368	11	10½	Lieuts Fraser and Mr Read.
–	–	–	43835	21918	–	Do	21927	1	8	Mr Read.
–	–	–	45349	22674	–	These works are situated at the point of departure of the Futtehgurh Branch Canal.	29776	14	3	Lt Fraser and Mr Read
–	–	–	4666	2333	–	Standard plan	1328	13	1	Do
–	–	–	976	488	–	Same as [illegible]	254	12	9	Do
–	–	–	30398	15199	–	This Bridge has a segmental arch with a [illegible] of 10'. Its [illegible] are [illegible] Foundations 10.75' deep.	16366	8	7	Do
–	–	–	976	488	–	Same as at [illegible]	264	13	5	Do
–	–	–	48885	24442	–	Same as at [illegible] but with [illegible] on [illegible] stream. Foundations 10' deep	25843	12	3	Do
–	–	–	18720	9360	–	Same as at Tagmoodpur	10827	–	2	Mr F Read
–	–	–	5182	2591	–	Do	2749	15	4	Do
–	–	–	47178	23589	–	Do	18153	11	8	Do

Chitowra Falls	55	7	9	1	8	25	5.5	2	18	316995	"	2377472
Terai 2nd Class Choki	58	4	177	2	.	.	.	.	-	2928	"	21960
Terai Bridge	58	5	40	..	3	55	10	2.75	18	89602	"	672015
Khutowli Bridge and Ghats	62	1	67	1	3	55	12	3	24	159520	"	1196550
Khutowli Escape	62	2	42	.	10	6	1.5	1.5	8½	57849	"	433867
Tutheri 2 Class Choki	64	3	143	.	.	.	.	.	-	2928	"	21960
Tutheri Bridge	64	4	61	2	3	55	10	2.75	18	123114	"	923355
Tullawar navigable Channel Head and [illegible] Rajouha Head	64	5	141	2	1	10	5	2	-	45658	"	342434
Tullawar 1st Class Choki	67	2	101	2	.	.	.	.	-	12602		94516
Tullawar Locks, Mills & Rajouha Head (Left)	67	2	144	1	3 (24.10' 14.15)				15	116233	"	871747
Tullawar Falls	67	2	191	2	6	25	5.5	2	18	325368	"	2440260
Abou's Nalla Escape	69	6	213	1	10	6	1.5	1.5	8½	56752	"	425640
Aternai 2 Class Choki	71	2	93	.	.	.	.	.	-	2761	"	20707
Aternai Bridge	71	3	6	2	3	55	10	2.75	18	74142	"	556065
Sirdhanna Bridge and Ghats	74	5	46	:	3	55	12	3	25	165018	..	1237635
Sirdhanna 1st Class Choki	74	6	199	1	.	.	.	.	-	12602	—	94515
Nanoo 2nd Class Choki	77	4	93	1	.	.	.	.	-	2928	—	21960
Nanoo Bridge	77	4	192	2	3	50	7	2¼	25	123243	-	924322
[illegible]froura 2nd Class Choki	79	7	73	.	.	.	.	.	-	2928	"	21960
[illegible]												

105664	52832	Same as at Mynoorpoor	55132	13 5	Dr Fraser and Mr Read –
976	488	Same as at Libenhein	276	12 6	Do
29868	14933	Same as at [illegible] Foundations 10' deep –	16527	2 ..	Do
53180	26590	Similar to [illegible] Bridge except that it has longer [illegible] passages through the abutments for the Towing Path. Foundations 12'	27529	6 10	Do
19283	9641	situated on the Right Bank of the Canal and forms the Head of an Escape Channel which empties itself into the [illegible]	11778	2 9	Do
976	488	Same as at [illegible]	241	5 8	Do
41038	20519	Same as at [illegible] Foundations 11'26"	20889	7 ..	Do
15219	6246	Same as Mynoorpoor	9349	9 1	Mr F Read
4201	2100	Standard Plan	1189	14 8	Dr Fraser and Mr Read
38744	19372	Same as at Mynoorpoor	13443	6 2	Mr F Read
108456	54228	Do but water way contracted to 150' –	57885	.. 9	Dr Fraser and Mr Read –
18918	9459	Similar to that at Khatowli [illegible] with [illegible] way –	10487	11 7	Mr F Read
920	460	Same as at Libenhein	281	7 11	Do
24714	12357	Same as Dukhein Foundations 7½'	16711	13 1	Do –
55006	27503	Similar to Khatowli Bridge Foundations 10⅔'	31571	12 ..	Dr Fraser and Mr Read
4200	2100	Standard plan	1176	1 10	Do
976	488	Do	274	6 6	Do
41080	20540	Here the width of Bridge is reduced to 150' in 3 Bays of 50' each. the arch is a segment with 7' versed sine. The [illegible] have a [illegible] [illegible] through them. [illegible] are provided on each Flank. Foundations 9'	20229	14 5	Do
976	488	Standard plan	275	2 11	Do

Jutpoora Bridge	79	7	168	-	3	50	7	2½	18	73300	"	549750
Pooth 2nd Class Choki	82	2	161	[illegible]	-	-	-	-	-	3394	"	25455
Pooth Bridge	82	3	38	-	3	50	7	2½	20	85418	"	640635
Bhola navigable Channel Head and Right Rajbuha Head	83	4	206	1	1	10	5	2	-	63822	"	478664
Bhola 1st Class Choki	84	1	183	2	-	-	-	-	-	12602	"	94516
Bhola Locks, Mills & Left Rajbuha Head	84	2	6	1	3/(2@10; 1@15)				15	147444	"	1105830
Bhola Falls	84	2	53	2	6	25	55	2	18	331105	"	2483287
Janni Escape	87	-	134	-	10	6	1.5	1.5	8½	69468	"	521010
Janni 2nd Class Choki	87	-	153	2	-	-	-	-	-	3033	"	22747
Janni Bridge	87	2	71	-	3	50	7	2½	20	78061	"	585457
Nugla 2nd Class Choki	89	5	55	-	-	-	-	-	-	3313	"	24847
Nugla Bridge	89	5	151	-	3	50	7	2½	20	77016	"	577620
Newarri 1st Class Choki	93	2	65	1	-	-	-	-	-	14112	"	10[illegible]820
Newarri Bridge	93	2	217	-	3	50	7	2½	18	71088	"	533160
Toundha 2nd Class Choki	96	1	41	1	-	-	-	-	-	3200	"	24000
Toundha Bridge	96	1	151	1	3	50	7	2½	18	71215	"	534112
Aboopoor 2nd Class Choki	98	3	35	2	-	-	-	-	-	3128	"	23460
Aboopoor Bridge	98	3	140	1	3	50	7	2½	18	71043	"	532820
Moradnuggur 2nd Class Choki	100	1	104	-	-	-	-	-	-	3128	"	23460
Moradnuggur Bridge & Ghats	100	1	208	1	3	50	7	2½	25	144034	"	1080255
Noorpoor 2nd Class Choki	102	7	203	1	-	-	-	-	-	3173	"	23797

–	–	–	24436	12213	–	Same as at Narrow-dale? without Shale. Foundation 13 feet	11954	6	8	Dr Fraser and Mr Read
–	–	–	1132	566	–	Standard plan	322	"	7	Mr F Read
–	–	–	28473	14236	–	Same as Sutformal? Foundations 15'75'	14926	5	5	Do
–	–	–	21273	9264	–	Same as at Nargmoodfa? except that this Road has a Shale 166 feet ... attached to it	11956	6	4	Do
–	–	–	4201	2100	–	Standard plan	1266	12	2	Dr Fraser and Mr Read
–	–	–	49148	24574	–	Same as a Sultanam?	24114	13	2	Mr F Read
–	–	–	110368	55184	–	Do	65520	6	8½	Dr Fraser and Mr Read
–	–		23156	11578	–	Same as the above ...	13204	3	7	Mr Read
–	–	–	1011	505	–	Standard plan	512	13	1	Do
–	–	–	26020	13010	–	Same as Sutfroma? Foundations 11'25 feet	14231	3	7	Do
–	–	1656	–	–	–	Standard plan	513	1	4	Do
–	–	38508		–	–	Same as Sutfroma? Foundations 16'75 feet	14434	7	5	Do
–	–	7056	–	–	–	Standard plan	1417	2	8	Do
–	–	35544	–	–	–	Same as Sutfroma? Foundations 10'75 feet	14528	10	6	Do
–	–	1600	–	–	–	Standard plan	371	14	1	Do
–	–	35607	–	–	–	Same as Sutfroma? Foundations 10 feet	12297	4	11	Do
–	–	1564	–	–	–	Standard plan	359	2	11	Do
–	–	35521	–	–	–	Same as Sutfroma? Foundations 11 feet	12749	6	1	Do
–	–	1564	–	–	–	Standard plan	376	4	8	Do
–	–	72017	–	–	–	Same as Sutfroma? but with Shale 160 feet long similar to the Sultanam? ones. Foundations 10 feet	22571	3	7	Do
–	–	1586	–	–	–	Standard plan	501	1	10	Do

Noorpoor Bridge	103	-	79	1	3	50	7	2½	18	62777	"	470827	
Dasna Navigable Channel Head and Right Rajbuha Head	104	7	125	..	1	10	5	2	-	45382	+	340364	
Dasnah 1st Class Choki	105	4	105	.	-	-	-	-	-	12602	+	94515	
Dasnah Locks Mills & Left Rajbuha Head	105	4	114	2	5/12	9/10	10	15	1.5	113566	+	851745	
Dasnah Falls	105	4	162	-	6	25	5.5	2	18	304886	+	2286645	
Pepulheera Bridge and Ghats	106	6	84	2	3	45	6	2½	20	129472	+	971040	
Raoli Bridge	108	5	84	.	3	45	6	2½	18	84506	+	633795	
Bolundshur Branch Head works													
Branch Regulating Bridge	110	2	96	.	3	1/12	6	1½	18	102817	282204	-	-
Main Canal Do	110	2	173	1	8	20	6	1½	18				
Duhera 1st Class Choki	110	3	..	-	-	-	-	-	-	12518	1,00,000		
Nahaoli Bridge	113	6	..		3	45	6	2½	18	75093	191,110	-	-
Nahaoli 2nd Class Choki	113	5	186	2	.	.	.	.	-	2659	23800	-	-
Gacha 2nd Class Choki	116	4	163	1	.	.	.	.	.	2659	22800	-	-
Gacha Bridge	116	5	6	-	3	45	6	2½	18	72137	250111	-	-
Geesoopoor 1st Class Choki	119	3	96	2	.	.	.	.	-	14222½	105460	-	-
Geesoopoor Bridge	119	6	110	.	3	45	6	2½	18	74390	219122	-	-
Sunowta 2nd Cl. Choki	122	4	153	1	-	-	-	-	-	2737	22800	-	.
Sunowta Bridge	122	5	44	1	3	45	6	2½	18	79894	199620	-	-
Pukhana 2nd Cl. Choki	125	4	153	1	-	-	-	-	-	2503	22800	-	-
Pukhana Bridge	125	5	35	1	3	45	6	2½	18	78211	123900	-	-

–	–	31388	–	–	–	Same as at Tullowra Foundations 11 feet	13604 11 4	Mr F Read
–	–	22690	–	–	–	Same as Tullawar	9355 11 6	Do
–	–	6301	–	–	–	Standard Plan	1544 10 3	Do
–	–	56783	–	–	–	Same as Tullawar	14190 11 2	Do
–	–	152443	–	–	–	Do	52639 12 8	Do
	–	64736	–	–	–	The water ways of bridges are here reduced to 135' and the design is altered by [illegible] being [illegible] and the [illegible] intact. Foundations 16.09	19046 12 6	Do
–	–	42053	–	–	–	Same as [illegible] bridge Foundations 17'12	15372 2 6	Do
110182	171	28621	–	–	–	These works are situated at the point of [illegible] of the [illegible] Branch and [illegible] Foundations from 5 to 15 feet deep	18757 10 4	Mr P Volk
–	36	673	–	–	–	Standard plan. 7' Foundation	1140 2 5	Do
[illegible]668	141	18260				Same as [illegible] but with 100 feet [illegible] Foundations 5½ to 6½' deep	9871 14 11	Do
–	7½	229	–	–	–	Standard plan 10' Foundation	271 10 4	Do
–	7½	158	–	–	–	Do Do	233 3 5	Do
[illegible]4590	130	14553½	–	–	–	Like Nishaoli - Foundation varying from 5½ to 7 feet	9070 4 9	Do
–	37	6197	.	24	–	Standard plan - [illegible] throughout. Foundation 9½'	1713 4 11	Do
[illegible]6128	135	16576	–	–	–	Like Nishaoli. Foundation from 5½ to 6½ feet	9827 10 11	Do
–	4	137	–	–	–	Standard Plan Foundation 6½	251 3 10	Do
[illegible]5593	87	11329	–	–	–	Like Nishaoli. Foundation from 8 to 9'	10975 5 10	Do
–	contract		–	–	–	Standard Plan - Foundation 5'	225 11 ..	Do
[illegible]875	130	17043	–	–	–	Like Nishaoli - Foundation 5½ to 6 feet deep	11035 6 1	Do

Dumkowa 1st Cl. Choki	128	4	120	-	-	-	-	-	-	9502	80000	-	-
Dumkowa Bridge	128	4	150	-	3	45	6	2½	18	64018	141350	-	-
Urrowli 2nd Class Choki	131	1	113	1	-	-	-	-	-	2893	27800	-	-
Urraoli Bridge	131	2	14	-	3	45	6	2½	25	103226	199722	-	-
Wullipoora Bridge	133	6	108	1	3	45	6	2½	26	140066	210977	-	-
Wullipoora 2nd Cl. Choki	133	6	208	1	-	-	-	-	-	2737	24800	-	-
Mamun 2nd Cl. Choki	137	-	100	-	-	-	-	-	-	2560	21800	-	-
Mamun Bridge	137	-	213	1	3	45	6	2½	18	78375	145414	-	-
Uchuhja Bridge	139	3	189	1	3	45	6	2½	18	68253	139614	-	-
Uchuhja 2nd Cl. Choki	139	6	86	-	-	-	-	-	-	2893	24450	-	-
Moonda Khera 1st Cl. Choki	140	-	83	1	-	-	-	-	-	13881½	100000	-	-
Moonda Khera Escape connected by Ghat wall	140	-	-	-	10	6	1½	1		} 178691	228184	-	
Moonda Khera Bridge	140	-	116	2	3	45	6	2½	18	}			
Tuhunda Bridge	144	5	6	-	3	45	6	2½	18	80147	113968	-	-
Tuhunda 2nd Cl. Choki	144	5	106	1	-	-	-	-	-	2560	21800	-	-
Pulra navigable Channel Head & Right Rajbuha (20% [illegible])	148	-	133	-	-	-	-	-	-	30653	36477	-	-
Pulra 2nd Class Choki	148	4	212	2	-	-	-	-	-	2513	14312	-	-
Pulra Falls	148	5	160	-	5	20	6	1½	18	174375	221141	-	-
Pulra Locks, Mills & Left Rajbuha Head	148	5	160		-	-	-	-	-	69827	83094	-	-
Kol Branch Headworks													
Branch Regulating Bridge	151	7	123	-	3	21 4/15	6	1½	18	} 87144	152445	-	-
Main Canal Do	151	7	145	-	6	26	6	1½	18	}			
Kol Branch Head 1st Class Choki	151	7	213	-	-	-	-	-	-	12859½	64114	-	-
Dadpoor 2nd Class Choki	155	3	114	-	-	-	-	-	-	2671	14312	-	-

-	25	402½	-	-	- 1	Standard plan. 2½ foundation	958	15	11	Mr P. Volk
50700	95	14974½	-	-	- 5	Similar to Nidhaoli but having no [illegible] in [illegible] heads & the [illegible] placed in downstream instead of [illegible] - foundations 5½ to 6½	8604	7	2	Do -
-	7	230	-	-	- 1	Standard plan. 7½ foundation	267	11	3	Do
69755	104	24512	-	-	- -	Differs from the Nidhaoli Br. only in shape of approach to [illegible] & in the details of [illegible]. Foundations 5½ to 8'	134[illegible]	6	-	Do
103447	168	34353½	-	-	-	Like the Nidhaoli Bridge but has shoots 350' long foundations 8 to 8½ feet -	17191	9	9	Do
-	6½	241	-	-	- 1	Standard plan. 6½ foundations	[illegible]	4	-	Do
-	2	58	-	-	- 1	Do 5½ foundation	229	6	8	Do
90300	77	19101	-	-	- 2	Like the Nidhaoli Bridge foundations 6' to 6'.2" -	10383	3	3	Do
36600	56½	15308	-	-	-	Same as Dumkowa Bridge foundations 7'.6 to 8'.6"	9017	2	7	Do
-	4	146	-	-	-	Standard plan. 7½ foundation	[illegible]	11	2	Do
	30	2640	-	- -	-	Do 6' " Pukka throughout				Do
128206	420½	53058	-	-	5 -	Escape and Bridge which is similar to Nidhaoli Bridge are connected together by a [illegible] 380' long. foundations 9'.7" to 10'.1" -	[illegible]976	[illegible]	4	Do
67300	134	19268	-	-	- 3	Like Nidhaoli. foundations 6'.6" to 6'.8"	10182	7	10	Do
-	5	150	-	-	- 1	Standard plan. 5½ foundation	248	3	-	Do
[illegible]478	22	8099	-	-	- 1	Same as at My[illegible]	-	-	-	Do
[illegible]200	7	273	-	-	-	Standard Plan. 5' foundations	324	10	-	Do
[illegible]302	117½	48318	-	-	- 2	Same as at [illegible] but water way increased to 100 feet -	} 31620	1	1	Do
[illegible]065	61	16449	-	-	- 1	Same as at [illegible]				Do
[illegible]100	236½	25385				Same as at B[illegible] Branch Head. Foundations 5 feet -	16752	14	9	Do
[illegible]500	20	1752				Standard Plan 7½ foundations	1485	1	1	Do
[illegible]500	8	497				Do 6' foundation	3[illegible]1	13	5	Do

Dadpoor Bridge	155	-	11	-	3	40	54	2½	18	71399	158594	-	-
Birowli 2nd Class Chokie	158	..	166	2	-	-	-	-	-	2513	14225	-	-
Birowli Bridge	158	1	62	..	3	40	54	2½	18	70702	156201	-	-
Dubtulla 2nd Class Chokie	161	1	46	2	-	-	-	-	-	2513	13757	-	-
Dubtulla Bridge	161	1	152	-	3	40	54	2½	18	71527	141280	-	-
Simra Navigable Channel Head & Right Rajbuha	162	6	25	-	-	-	-	-	-	30653	45979	-	-
Simra 2nd Class Chokie	163	2	82	-	-	-	-	-	-	2394½	14432	-	-
Simra Falls	163	3	61	-	5	20	6	1½	22	186063	276304	-	-
Simra Locks Mills & Left Rajbuha Head	163	3	61		-	-	-	-	-	74790	112185	-	-
Kasimpoor 1st Cl: Chokie	166	3	100	..	-	-	-	-	-	14392½	22163	-	-
Kasimpoor Escape connected by Shats with	166		31	2	10	6	1½	1	—	165707	267957	-	-
Kasimpoor Bridge	166	3	160	.	3	40	54	2½	18				
Burotha 2nd Cl: Chokie	170	-	46	2	-	-	-	-	-	2829	11000	-	-
Burotha Bridge	170	-	163	1	3	40	54	2½	22	76564	152749	-	-
Machoora 2nd Cl: Chokie	172	7	186	-	-	-	-	-	-	2829	13632	-	-
Machoora Bridge	173	-	83	.	3	40	54	2½	18	69098	142808	-	-
Chungeyri 2nd Cl Chokie	175	3	58	.	-	-	-	-	-	3145	14000	-	-
Chungeyri Bridge	175	3	171	2	3	40	54	2½	18	59809	131500	-	-
Sheka 2nd Class Chokie	177	6	95	.	-	-	-	-	-	2987	16000	-	-
Sheka Bridge	177	6	212	.	3	40	54	[illegible]½	22	78118	153500	-	-
Nanoon Headworks													
Cawnpoor Branch Regulating Bridge	180	7	52	..	5	20	6	1½	25	132228	228400	-	-
Etawa Do	180	6	146	:	5	20	6	1½	25				
Nanoon 1st Class Chokie	180	7	102	-	-	-	-	-	-	13881½	76000	-	-

42005	84	21833			–	Same as Redhadee, but waterway reduced to 120 feet. 6' Foundations	10125	3	7	Morvolk.
1200	9	497	–	–	–	Standard Plan 5' foundation	334	8	11	Do
57043	74	21485	–	–	–	Same as Daofrom - 5'11" Foundation -	9316	3	10	Do
1200	9	382	–	–	–	Standard Plan 5' foundation	347	3	7	Do
42250	88½	23678	–	–	–	Same as Daofrom. 6'11" foundn	9867	13	2	Do
14311	26½	9140	–	–	–	Same as Pulen }				Do
1200	5	255	–	–	–	Standard Plan 4½' foundation }	33982	5	8	Do
123790	198	54417	–	–	–	Same as Pulen }	360	6	10	Do
47117	66	22302	–	–	–	Do }				Do
8400	–	3866	–	–	–	Standard Plan Pukka throughout 9½' foundation	1720	14	9	Do
94553	9½	48036	–	–	–	Same as at Moondakhera foundation 7'11".	20415	9	..	Do
1300	–	236	–	–	–	Standard Plan 7' foundation	344	11	11	Do
57912	56	23953	–	–	–	Same as Daofrom 7' foundn	10751	11	8	Do
1300	–	228	–	–	–	Standard Plan 7' foundn	360	12	8	Do
25344	51	21907	–	–	–	Same as Uchulyia except width of water way - 5 6 feet foundation	10224	11	1	Do
1600	–	455	–	–	–	Standard Plan 9' foundation	344	12	6	Do
58705	49	19436	–	–	–	Same as Machora. 6'3" foundation	10120	6	1	Do
1360	–	185	–	–	–	Standard plan 8' foundation	348	14	8	Do
43800	82	23611	–	–	–	Same as Machora 5'6 feet foundation	12048	1	3	Do
103325	105	36137	–	–	–	Same as Bolundshahr 6 feet foundation	20864	14	11	Do
10200	–	2132	–	–	–	Standard plan - 9' foundn	1026	13	3	Do

Etawah Terminal Line

Chitrowli 2nd Class Choki	2	5	12	2	-	-	-	-	-	4160	14400	-	-
Chitrowli Bridge	2	5	112	2	3	33	4½	2½	18	71001·63	97808	-	-
Bujrungpoor 2nd Class Choki	4	4	112	2	-	-	-	-	-	3329	15800	-	-
Bujrungpoor Bridge	4	4	213	1	3	33	4½	2½	18	71627·232	99200	-	-
Bijeegurh 2 Class Choki	7	4	85	-	-	-	-	-	-	3480	16200	-	-
Bijeegurh Bridge	7	4	212	2	3	33	4½	2½	18	69207·582	91488	-	-
Jao 1st Class Choki	10	4	163	1	-	-	-	-	-	16064	70000	-	-
Jao Bridge	10	5	17	1	3	30	4	2½	18	68601	85119	-	-
Lodipoor 2nd Cl: Choki					-	-	-	-	-	2778	14600	-	-
Lodipoor Bridge	13	1	152	-	3	30	4	2¼	18	59687·49	92728	-	-
Kutai 2nd Class Choki	15	2	187	1	-	-	-	-	-	3643	2000	-	-
Kutai Bridge	15	3	110	1	3	30	4	2½	18	64812·12	86791	-	-
Seetapoor 2nd Cl: Choki	17	7	158	1	-	-	-	-	-	3284	14600	-	-
Seetapoor Bridge	18	-	92	-	3	30	4	2½	18	59687	83666	-	-
Pilkutra 1st Cl: Choki	20	5	161	1	-	-	-	-	-	14988	63350	-	-
Pilkutra Bridge	20	6	44	-	3	30	4	2½	18	61110·5	89528	-	-
Noh 2 Class Choki	23	2	21	2	-	-	-	-	-	3580	15500	-	-
Noh Bridge	23	2	219	-	3	30	4	2½	18	68350·9	94287	-	-
Oreynee 2nd Cl: Choki	25	5	135	-	-	-	-	-	-	3350	15500	-	-
Oreynee Bridge	25	6	10	2	3	30	4	2½	18	66758	102143	-	-
Gulirana Bridge	28	2	89	-	3	30	4	2½	18	39693·8	37600	-	-

[illegible]442	2	350	–	–	–	Standard Plan – Block kunkur foundations	468	11	6	By Writing
58775	104	13568	–	–	–	Design similar to foregoing Bridge but water way reduced to 99 feet – and Ghats only 60 feet long. Rajbaha Outlet Heads attached the former 10 ft wide and floor 2 ft below bed of Canal. Foundation 6'.	10046	14	1	Do
[illegible]443	2	300	–	–	100	Same as Chitrowli	388	12	8	Do
[illegible]9235	264	15491	–	–	464	Same as Chitrowli	10837	13	9	Do
[illegible]054	2½	340	–	–	–	Do	399	4	3	Do
[illegible]900	196	14526	–	–	–	Do except in shape of Cornice and having Piers prolonged – & face of Arches with Block kunkur	10293	1	4	Do
8000	20	2576	–	–	170	Standard plan except that roof [illegible] to form a Stair case –	2531	7	7½	Do
[illegible]406	218	14163	–	–	–	Same as Chitrowlee – but water way reduced to 90'	10889	8	1	Do
1045	–	438	–	–	–	Same as Chitrowli [illegible] with Block kunkur –	365	1	10½	Do
[illegible]113	234	13187	–	–	–	Do	[illegible]876	2	7	Do
[illegible]43	–	430	–	–	–	Do but [illegible] of Block kunkur except Arches	1672	8	..	Do
[illegible]286	227	11857	–	–	–	Same as Chitrowli – Arches faced with kunkur –	9698	7	10	Do
1552	–	330	–	–	120	Same as Chitrowli	432	12	4½	Do
[illegible]838	226	13252	–	–	810	Do Arches faced with Block kunkur	9479	2	1	Do
[illegible]505	14	1900	–	–	–	Same as Do –	1453	8	10	Do
[illegible]840	243	13082	–	–	943	Same as Chitrowli	9489	14	3	Do
[illegible]700	–	385	–	–	–	Do	442	.	8	Do
[illegible]568	120	12916	–	–	410	Do	9094	7	..	Do
1500	–	380	–	–	–	Do	415	2	2	Do
[illegible]980	145	14504	–	–	–	Do	8936	10	11	Do
[illegible]105	32	8127	–	–	490	Do but has no Ghats. Rajbaha Heads &c –	5341	15	..	Do

Sonari 2d Class Choki	31	1	180	-	-	-	-	-	-	3805	1600	-	-
Sonari Bridge	31	2	57	..	3	26	3½	2½	18	63391·1	82785	-	-
Soraoon 1st Class Choki	33	3	40	-	-	-	-	-	-	16285	72000	-	-
Soraoon Bridge	33	3	161	-	3	26	3½	2½	18	63907·4	98654	-	-
Kutana 2d Class Choki	35	6	46	2	-	-	-	-	-	3327·	16000·	-	-
Kutana Bridge	35	6	134	-	3	26	3·5	2½	18	63907·4	102204	-	-
Jeyra 2 Class Choki	39	1	-	-	-	-	-	-	-	3290	16200	-	-
Jeyra Bridge	39	1	120	-	3	26	3½	2½	18	64501·5	70850·	-	-
Peydhut 2 Cl: Choki	41	.	11	-	-	-	-	-		3290·5	13200	-	-
Peydhut Bridge	41	-	90	2	3	26	4	2	18	65325·8	81300	-	
Ka.atiowa 2nd Class Choki	43	1	93	1	-	-	-	-	-	3290	13200	-	-
Kana Kowa Bridge	43	1	166	2	3	26	4	2	18	61354·5	68500	-	-
Puteeka 1st Cl: Choky	46	3	93	1	-	-	-	-	-	16620	65000	-	-
Puteeka Bridge	46	3	216	2	3	26	4	2	18	62074·9	88000	-	-
Burragum 2d Class Choki	49	·3	126	2	-	-	-	-	-	3290·5	13200	-	-
Burragam Bridge	49	4	11	2	3	26	4	2	18	59167·4	1,00000	-	-
Koosiarri 2nd Class Choki	52	3	36	2	-	-	-	-	-	3171·5	13200	-	-
Koosiarri Bridge	52	3	136	2	3	26	4	2	18	58767·5	200000	-	-
Futteh Khani 2nd Class Choki	54	7	40	-	-	-	-	-	-	3171·5	13200	-	-
Futteh Khani Bridge	54	7	140	1	3	26	4	2	18	56954·5	138000	-	-
Jehror 1st Cl: Choki	57	4	61	1	-	-	-	-	-	15238·	60000	-	

3000	..	430	–	–	–	Block kunkur noted throughout except in [illegible]	580	11	1	Capt. Whiting
52894	111	13082	–	–	537	At this bridge the water way is reduced to 78 feet, and the Ray [illegible] heads are only 6 feet wide with flooring 18 inches above [illegible]	8521	1	7	Do
7777	4¼	2160	–	–	140	Same as at Jao	2224	6	7	Do
31356	135	11622	–	–	438	[illegible] with kunkur	8353	..	4	Do
1443	3	270	–	–	106	Same as Chitowli	409	8	6	Do
30080	126	12000	–	–	1080	Same as Soraon Bridge	8442	13	..	Do
1534	2½	280	–	–	112	Same as Chitowli	413	4	11	Do
55940	93	12006	–	–	550	Same as Soraon Br:	8494	14	9	Do
1593	–	361	–	–	60	Same as Chitowli	433	12	11	Do
33164	72	15170	–	49	225	Same as Soraon, but [illegible] are 107 feet long	9073	11	4	Do
1693	–	300	–	–	115	Same as Chitowli	415	2	7½	Do
32789	63	16490	–	39	750	Same as Soraon	7570	10	9	Do
8600	9	3043	–	–	1447	Same as at Jao but [illegible] throughout	2344	14	..	Do
11067	38	18150	–	–	–	Same as Soraon but [illegible] are 73 feet long	8661	2	9	Do
1593	–	362	–	–	57	Same as Chitowli	433	10	8	Do
26710	28	14290	–	–	–	Same as [illegible]	8055	6	..	Do
1474	–	639	–	–	288	Same as Chitowli but [illegible] throughout	472	2	11	Do
33180	14	14905	–	–	–	Same as Soraon except that [illegible]	8869	12	6	Do
1474	–	236	–	–	200	Same as Chitowli	410	13	5	Do
39697	60	14122	–	–	.	Same as Kossiani	6392	15	..	Do
7725	17	2398	–	156	868	Same as Jao	2377	13	10	Do

Gihror Bridge and connected Escape and extra Bridge over Escape Channel -	57	4	158	-	2	33	4	2	25	134699	180000	-	-

Cawnpoor Terminal Line

Keylunpoor 2nd Class Choki	2	5	165	.	-	-	-	-	-	3517	1925	28200	
Keylunpoor Bridge	2	6	34	2	3	33	4	2½	20	81543	317115	69655	-
Rudaun 2nd Cl. Choki	6	2	65	2	.	.	.	.	-	3820	1800	40812	-
Rudaun Bridge	6	2	160	.	3	33	4	2½	18	61391	388417	-	-
Ginnoudi Escape	9	2	4	-	3	6	1	1	5	14231	85200	-	-
Ginnoudi 2nd Cl. Choki	9	2	62	-	.	.	.	.	.	3460	7500	23000	-
Ginnoudi Bridge	9	2	113	1	3	33	4	2½	18	61421	368480	-	-
Barumai Bridge	11	2	186	2	3	33	4	2½	20	47860	347580	-	-
Thunder 1st Class Choki	12	1	133	1				.	.	13283		-	
Ponditnuggur Bridge	12	7	215	.	3	33	4	2½	20	63057	192338	219394	-
Sirsoul 2nd Cl. Choki	15	7	29	1	-	-	-	-	-	2723	26738	-	
Sirsoul Bridge	15	7	116	2	3	33	4	2½	18	61832	136252	200004	-
Punsor 2nd Cl. Choki	19	2	122	2	-	.	.	.	.	3862	34809	-	
Punsor Bridge	19	2	213	1	3	33	4	2½	18	62602	210910	-	-
Cuttupoor 1st Cl. Choki	22	5	106	2	-	-	-	-	.	14882	-	118510	-
Cuttupoor Bridge	22	6	5	-	3	32	4	2½	18	65779	-	161750	-
Burdi 2nd Cl. Choki	26	6	50	..	-	-	-	-	-	3470	7479	13080	-
Burdi Bridge	26	6	136	2	3	31	4	2½	18	54808	175441	66030	-
Guddunpoor 2nd Cl. Choki	29	2	189	1	-	-	-	-	-	2874	17048	-	-
Guddunpoor Bridge	29	3	56	2	3	30	4	2	20	58088	310793	-	-

112337	85	34248	–	–	–	To design of [illegible] to those at [illegible]	18009	4 3	Capt. Whiting
–	–	73	–	53½	–	Standard plan	369	3 9	[illegible] Hodgson
9787		25668	–	–	4310	[illegible] 100 feet long [illegible]	11742	11 7	do
–	–	26	–	17½	–	Standard plan	39[illegible]	[illegible]	do
	2224g	–	–	1620	7398	Same [illegible] but without drop in floor	10192	[illegible] 10	do
2270		5800	–	–	1136	[illegible] with bridge	2213	5 9	do
–	–	122	–	38	52½	Standard plan	462	12 .	do
9663	–	24073	–	501½	4951	Same as Cadair	10071	14 9	do
		18117	–	1326	3157	Same as Cadair [illegible]	6190	16 7	do
–	–	–	–	–	–	Standard plan	1250	12 1	do
11064	–	24449		2665	5262	Same as Cadair	10659	13 0	do
–	–	131	–	78½	–	Standard plan	310	4 8	do
13352		18631	–	2084	5339	Same as Cadair	9930	7 6½	do
–	–	156	–	48	–	Standard plan	455	3 6	do
38276		20278	–	3179	5726	Same as Cadair	9627	. 9	do
264	–	1762	–	61	37	Standard plan	2006	14 11	do
22291	–	26107	–	30	5932	Same as Cadair except [illegible]	10935	1 5	do
1200	–	199	–	–	16	Standard plan	402	2 2	do
32492	–	16826	–	236	2770	Same as Cadair	9390	13 .	do
–	–	144	–	–	96	Standard plan	393	14 ?	do
7224	–	15779	–	1102	5534	Same as Cadair	9824	6 1	do

Gopalpoor 1st Cl. Chokee	32	6	204	2	-	-	-	-	-	13926	66352	-	-
Gopalpoor Bridge	32	7	73	1	3	29	4	2	18	54819	302325	-	-
Dharoo 2nd Cl. Chokee	35	4	120	-	-	-	-	-	-	2895	23760	-	-
Dharoo Bridge	35	4	205	-	3	29	4	2	18	54142	233200	-	-
Keylai 2nd Cl. Chokee	38	5	89	1	-	-	-	-	-	2841	-	29407	-
Keylai Bridge	38	[illegible]	170	-	3	29	4	2	20	58402	183746	79909	-
Khoreet 2nd Class Chokee	41	4	199		-	-	-	-	-	2777	19110	-	-
Khoreet Bridge	41	5	76	2	3	28	4	2	18	54233	105192	-	-
Mohumpoor 1st Class Chokee	44	7	4		-	-	-	-	-	14270	96538	21513	-
Mohumpoor Bridge	44	7	126	2	3	28	4	2	20	55414	232064	27942	-
Nuggureea Escape	47	7	170	-	5	6	1	1	-				
Nuggureea 2nd Cl. Chokee	48	-	35	-	-	-	-	-	-	3102	23424	-	-
Nuggureea Bridge	48	-	133	1	3	28	4	2	18	52131	180815	-	-
Puchowa 2nd Cl. Chokee	50	4	216		-	-	-	-		2339	21588	-	-
Puchowa Bridge	50	5	83	1	3	27	4	2	21	53538	125435	-	-
Nuzaoli 2nd Cl. Chokee	54	-	123	-	-	-	-	-	-	3122	26532	-	-
Nuzaoli Bridge	54	-	205	1	3	27	4	2	18	52480	212863		
Dunnahai 1st Cl. Chokee	57	4	124	1	-	-	-	-	-	14315	-	60551	-
Dunnahai Bridge	57	4	213	1	3	26	4	2	25	64206	107303	15800	-
Roostumpoor 2nd Cl. Chokee	60	7	110	-	-	-	-	-	-	2997	22576	-	
Roostumpoor Bridge	60	7	215	1	3	26	4	2	20	53800	99818	-	-
Singhpoor 2nd Cl. Chokee	64	5	203	1	-	-	-	-	-	2881	11850	10693	-
Singhpoor Bridge	64	6	63	1	3	26	4	2	20	53602	110841	-	-
Putturhai 2nd Cl. Chokee	67	4	145	1	-	-	-	-	-	2997	-	26530	-
Putturhai Bridge	67	5	8	1	2	35	4½	2½	18	46810	23295	82270	-
Bhawunt 1st Cl. Chokee	70	3	131	2	-	-	-	-	-	13985	32206	-	-

6000	-	1434	-	-	326	Standard plan	1824 12 2	A Hodgson
20852	-	14140	-	1028	3296	Same as Leadair with Ventilation to Lay[illegible] Openings which are Reduced to 6 feet -	8946 4 7	do
-	-	328	-	-	39	Standard plan	463 13 -	do
280[illegible]	-	13392	-	-	5334	Same as [illegible]	8551 5 6	do
-	-	159	-	-	25	Standard plan	351 7 11	do
22477	-	15763	-	1026	7417	Same as [illegible]	10007 9 3	do
-	-	72	-	108	64	Standard plan	349 - 1	do
[illegible]1897	-	17820	-	-	2386	Same as [illegible]	[illegible]402 15 7	do
-	-	555	-	203	79	Standard plan	1500 2 10	do
[illegible]2777	-	17105	-	190	6529	Same as [illegible]	9902 1 3	do
							3340 5 11	do
-	-	172	-	-	8	Standard plan	347 1 3	
[illegible]334	-	16231	-	-	8138	Same as [illegible]	8850 6 3	do
-	-	219	-	50	36	Standard plan	331 14 1	
[illegible]6		18538	-	-	11562	Same as [illegible]	[illegible] 3 7	do
-	-	175		38	16	Standard plan	360 5 3	do
[illegible]236		18249		1077	3409	Same as [illegible] but no retaining [illegible]	8649 4 6	do
[illegible]912	-	2382	-	-	326	Standard plan	2133 13 11	do
[illegible]815	-	20301	-		10606	Similar to [illegible] but [illegible] 80 feet [illegible]	12419 1 4	do
-	-	348	-	-	-	Standard plan	393 15 1	do
[illegible]478	-	20871	-	-	11787	Same as [illegible]	9635 1 2	do
-	-	324	-	66	82	Standard plan	373 7 1	do
[illegible]171	-	19038	-	68	9992	Same as [illegible]	9895 7 4	do
-	-	262	-	$11\frac{1}{2}$	50	Standard plan	401 3 10	do
[illegible]390	-	20772	-	-	12706	Same as [illegible] but 2 Bays instead of 3	8025 - 6	do
[illegible]47		1678	-	-	472	Standard plan	1857 13 3	do

Bhawount Bridge	70	3	210	-	2	35	4½	2½	20	56951	133520	15193	-
Togaon 2nd Cl. Chokee	74	1	138	-	-	-	-	-	-	2859	13867	-	-
Togaon Bridge	74	2	2	1	2	33	4½	2½	18	49117	125413	5700	-
Kussuda 2nd Cl. Chokee	77	1	151	2	-	-	-	-	-	2984	15868	-	-
Kussuda Bridge	77	2	5	1	2	33	4½	2½	18	43400	129051	-	-
Kynan 2nd Cl. Chokee	80	4	136	2	-	-	-	-	-	3096	25358	-	-
Kynan Bridge	80	4	213	2	2	33	4½	2½	18	46665	189163	34216	-
Chundos 1st Cl. Chokee	82	6	130	2					-	10671	48941	-	-
Chundos Bridge	82	7	10	2	2	33	4½	2½	18	[illegible]	178450	-	-
Sirrsa Escape	87	-	185	1	5	6	1	1		17437	38608	3625	-
Sirsa 2nd Cl. Chokee	87	1	31	2			-	-	-	2728	[illegible]407	10300	-
Sirsa Bridge	87	1	67	.	2	32	4½	2½	20	48047	155497	9670	-
Futtehpoor 2nd Cl. Chokee	90	2	187							2730	13402	-	-
Futtehpoor Bridge	90	3	57		2	32	4½	2½	18	48320	162126	-	-
Mirzapoor 2nd Cl. Chokee	93	-	205	-	-	-	-	-	-	2687	15394	-	-
Mirzapoor Bridge	93	1	70	2	2	30	4	2	20	45001	264717	-	-
Dingurea 1st Cl. Chokee	96	4	86	1	-	-	-	-	-	not begun			
Dingurea Bridge	96	3	178	2	2	30	4	2	18	49170	117513	-	
Tureya 2nd Cl. Chokee	98	4	32						-	2687	15510	-	
Tureya Bridge	98	4	115	1	2	30	-	2	20	44457	132437	-	-
Kunsowa 2nd Cl. Chokee	102	2	14	-	-	-	-	-	-	2580	22200	-	
Kunsowa Bridge	102	2	78	2	2	30	4	2	18	47255	60842	-	-
Husseyn 2nd Cl. Chokee	104	5	143			-	-	-	-	2580	19385	-	-
Husseyn Bridge	104	6	29	1	2	30	-	2	20	66949	[illegible]210	-	-
Bahosi 1st Cl. Chokee	108	5	59	1	-	-	-	-	-	9260	76403	-	
Bahosi Bridge	108	5	132	-	2	30	4	2	18	50893	19223	-	
Gonaba 2nd Cl. Chokee	111	-	4	2	-	-	-	-	-	2580	18975	-	

22812	–	17049	–	1908	10260	Same as Pattihar	9403 14 4	J. Hodgson
1326	–	180	–	–	62	Standard plan	435 15 11	do
30849	–	15596	–	2024	10262	Same as Pattihar but with reversed water way –	8649 2 9	do
1372	–	244	–	10	106	Standard plan	407 13 4	do
13926	–	13100	–	1260	9040	Same as Logaon	7095 4 5	do
–	–	315	–	4	44	Standard plan	396 . 4	do
18196	–	13652	–	1690	8796	Same as Logaon	7617 1 1	do
1313	–	264	–	–	68	Standard plan [illegible]	– – –	do
30161	–	15699	–	–	10370	Same as Logaon but with [illegible]	not [illegible]	do
11470	–	5503	–	–	4291	Same as Nugawan	2792 10 7	do
702	–	44	–	–	44	Standard plan	–	do
23397	–	13568	–	–	7915	Same as Dhundas	– – –	do
780	–	66	–	–	19	Standard plan	– –	do
20317	–	12331	–	–	8058	Same as Dhundas	– – –	do
534	–	52	–	–	52	Standard plan	327 14 7	do
19499	–	11680	–	–	7730	Same as Dhundas but with reversed water way –	– – –	do
						[illegible]		
14448	–	8230	–	–	5374	Same as Mirzapur	– – –	do
742	–	95	–	–	11	Standard Plan	324 1 10	do
20599	–	13968	–	–	6968	Same as Mirzapur	– – –	do
–	–	145	–	–	85	Standard plan	310 2 6	Lt Hutchinson & Lt Hodgson
21164	–	11243	–	2615	6649	Same as Mirzapur	– – –	do
–	–	30	–	30	–	Standard plan	353 1 1	do
22097	–	11456½	–	9440	730	Same as Mirzapur	10286 15 1	do
2162	–	1147	–	930	–	Standard plan	1759 10 –	do
18712	–	10827	–	8130	1424	Same as Mirzapur	8057 2 –	do
–	–	195	–	60	–	Standard plan	308 9 –	do

Yonaka Bridge	111	-	74	-	2	30	4	2	18	63299	18737	-	-
Oomurda 2 Cl. Choki	113	6	117	-	-	-	-	-	-	2580	19932	-	-
Oomurda Bridge	113	7	16	2	2	30	4	2	18	45917	22364	-	-
Tolki 2 Cl. Choki	115	6	195	2	-	-	-	-		2580	18675	-	-
Tolki Bridge	115	7	26	2	2	25	4	2	15	44003	63510	-	-
Khyrnuggur 2 Cl. Choki	118	7	209	-	-	-	-	-	-	2580	18110	-	-
Khyrnuggur Bridge	119	-	64	2	2	25	4	2	16	52508	53301	-	-
Rima 1 Cl. Choki	122	-	166	2	-	-	-	-	-	12365	97343	-	-
Rima Bridge	122	-	200	-	2	25	4	2	15	45487	49202	-	-
Bunafoor Bridge	124	6	164	2	2	25	4	2	15	31846	61390	-	-
Bidhun 2 Cl. Choki	127	1	13	-	-	-	-	-	-	2580	18920	-	-
Bidhun Bridge	127	1	100	-	2	25	4	2	18	44982	65412	-	-
Ootha 2 Cl. Choki	130	-	168	2	-	-	-	-	-	2580	18918	-	-
Ootha Bridge	130	-	210	-	2	25	4	2	18	44783	160028	-	-
Munowa 2 Cl. Choki	132	6	167	1	-	-	-	-	-	2580	18918	-	-
Munowa Bridge	132	7	1	2	2	25	4	2	18	42824	299815	-	-
Kukwan Escape	134	7	173	2	5	6	1	1	-	20419	120868	-	-
Kukwan 1 Cl. Choki	135	-	57	-	-	-	-	-	-	9435	73337	-	-
Kukwan Bridge	135	-	149	2	2	25	4	2	20	45102	307709	-	-
Mudoofoor 2 Cl. Choki	138	-	115	1	-	-	-	-	-	2580	19018	-	-
Mudoofoor Bridge	138	-	160	-	2	25	4	2	18	49609	112298	-	-
K?oondun Bridge	140	3	41	2	2	25	4	2	15	32119	68113	-	-
Juktowli 2 Cl. Choki	142	3	47	-	-	-	-	-	-	2580	19016	-	-
Juktowli Bridge	142	3	116	2	2	25	4	2	18	48740	121193	-	-
Bhosun 2 Cl. Choki	145	1	114	2	-	-	-	-	-	2580	17538	-	-

16052	-	13836	-	11025	-	Same as Musseegum	10561	9	4	D. Hutchinson & H. Hodgson
-	-	45	-	-	5	Standard plan	380	13	3	do
16063	-	10300	-	8620	-	Same as Musseegum	8853	15	7	do
-	-	171	-	105	-	Standard plan	360	9	2	do
?063	-	8743	-	7248	-	Same as Musseegum but with [illegible]	6287	1	5	do
-	-	100	-	60	-	Standard plan	351	13	3	do
?0824	-	12143	-	10291	-	Same as Toolkee	6551	6	11	do
400	-	925	-	650	50	Standard plan	1,748	2	11	do
?2771		8034	-	10344	821	Same as Toolkee	6842	5	5	do
?710	-	9939		-	5255	do but with [illegible]	4999	14	1	do
		90		183	-	Standard plan	373	13	1	do
?445	-	9017	-	6143	1825	Same as Toolkee	6530	1	4	do
	-	96	-	190	-	Standard plan	355	14	..	do
?413	-	8810	-	6730	893	Same as Toolkee	6765	3	2	do
-	-	241	-	375	-	Standard plan	386	14	4	do
-	-	9849		6203	1479	Same as Toolkee	7311	1	3	do
?127	-	7626	-	-	5598	Same as Tingurrea	3214	2	10	do
-	-	1117	-	1169	-	Standard plan	[illegible]	[illegible]	[illegible]	do
-	-	10721	-	5263	2682	Same as Toolkee	7334	2	7	do
-	-	166	-	221	-	Standard plan	343	8	.	do
?7129	-	10071	-	7703	870	Same as Toolkee	7922	14	3	do
?0740	-	10112	-	-	5918	Same as Banafore	5238	7	6	do
-	-	118	-	99½	-	Standard plan	355	9	7	do
?3224	-	8698	-	4327	827	Same as Toolkee	6744	11	7	do
-	-	146	-	62½	-	Standard plan	349	9	4	do

Bhosan Bridge	145	1	158	1	1	30	4	2	20	43835	205938	–	–
Juggutpoor 1st Cl. Chokie	147	-	111	2	-	-	-	-	-	16012	92929	–	–
Juggutpoor Bridge	147	-	208	1	1	30	4	2	18	44266	31988	–	–
Runjeetpoor 2nd Cl. Chokie	150	1	148	2	-	-	-	-	-	2580	18918	–	–
Runjeetpoor Bridge	150	2	3	1	1	30	4	2	18	36093	190853	–	–
Hookapoor 2nd Cl. Chokie	153	2	57	-	-	-	-	-	-	2580	20877	–	–
Hookapoor Bridge	153	2	165	-	1	30	4	2	-	35645	240793	–	–
Koosoulie 2nd Cl. Chokie	156	-	136	2	-	-	-	-	-	2580	19436	–	–
Koosoulie Bridge	156	-	210	-	1	30	4	2	18	41652	275254	–	–
Bana Bridge	158	3	73	1	1	30	4	2	18	41910	208619	–	–
Bana 1st Cl. Chokie	158	5	3	1	-	-	-	-	-	-	58010	–	–
Museeanpoor Bridge	161	-	111	-	1	25	4	2	15	35617	233273	–	–
Khujoori 2nd Cl. Chokie					-	-	-	-	–	2580	14341	–	–
Khujoori Bridge	162	4	76	2	1	25	4	2	20	57439	375940	–	–
Dubrowli Escape	16[illegible]	4	126	1	-	-	-	-	-	48426	318913		–
[illegible]urowli Regulator	16[illegible]	5	206	1	1	20	2½	1⅞	18	25185	[illegible]	–	–
[illegible] [illegible] Road Bridge	16[illegible]	3	196	2	1	20	2⅔	2	25	27785	76284	108521	–

12052	-	10936	-	2510	3791	Design similar to [illegible] but with only 1 water way	6792 12 9	A Hutchinson F. W. Hodgson
132	-	472½	-	810	-	Standard plan	1685 9 7	do
38812	-	8978	-	3445	2855	Same as Bhosan	6737 6 5	do
[illegible]	-	320½	-	210	-	Standard plan	353 8 10	do
11384	-	8389	-	4356	2474	Same as Bhosan	not completed	do
-	-	64	-	41	-	Standard plan	371 4 11	do
291	-	10126	-	3078	2530	Same as Bhosan	not completed	do
-	-	53	-	52	-	Standard plan	344 2 9	do
-	-	10562	-	4606	2921	Same as Bhosan	not completed	do
-	-	5258	-	4768	456	Do	5606 . 2	do
-	-	623	-	316	202½	Standard plan	1421 12 7	do
1680	-	7702	-	5396	1398	Same as Bhosan	not completed	do
-	-	80	-	39	37½	Standard plan	349 12 4	do
3084	-	13826	-	5877	488	Same as Bhosan, but on a Skew of an angle of 53°. Revetments [illegible] and [illegible] Heads arranged so as to give [illegible] to the front	4301 10 6	do
-	-	17852	-	605	775	An Escape of 38 openings [illegible]	not completed	[illegible] Hodgson
-	-	9705	-	306	205	None are provided [illegible]	do	do
[illegible]	-	6486	-	241	2229	This is the [illegible] Pilasters and [illegible]	do	[illegible] Hutchinson F. W. Hodgson

Cawnpore Works

No 1 Swing Bridge	168	1	185	1	1	20	2⅓	1½	20	13879	63956	–	–	
2 Do	168	2	166	–	1	20	2⅓	1½	20	12403	64386	–	–	
3 Do	168	3	165	–	1	20	2⅓	1½	20	12328	60901	–	–	
4 Do	168	4	161	–	1	20	2⅓	1½	20	1164[illegible]	67602	–	–	
5 [illegible] Do	168	6	128	2	1	20	2⅓	1½	20	9246	63000	–	–	
6 [illegible] Bridge	168	7	118	–	1	20	2⅓	1½	30	18032	118804	–	–	
No 1 Lock	169	–	133	1						8311	272781	15950	–	
Town Road Bridge	169	3	47	2	1	20	2⅓	1½	30	19185	71000	–	–	
No 2 Lock	169	4	126	1										
3 Do	169	4	167	2	–	–	–	–	–	474[illegible]	31312	21880		
4 Do	169	5	151	2										
5 Do	169	5	192	2	–	–	–	–	–	–	–	–	–	–
Terminal Works	169	6	13	2	–	–	–	–	–	–	152185	–		
Canal and Esplanade to [illegible] [illegible] [illegible]	–	–	–	–	–	–	–	–	–	–	1241618	820106	–	

… each work executed on the Ganges Canal …

6								7	8	9
…als Expended										
Boulders	Brick	Kunkur	Lime Stone	Lime Kunkur	Lime Earth	Soorkhi	Sand Bujree	Description of the Work	Value of the Work	Name of the Executive Engineer in Charge and …
…	Cubic Feet		Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet			
–	–	[illegible]	–	2153	–	–	2224	[illegible]		G. Hutchinson [illegible]
–	–	[illegible]	–	2323	–	–	2268			
–	–	[illegible]	–	2175	–	143	2038			
–	–	[illegible]	–	1957	–	1957	–			
–	–	[illegible]	–	2100	–	496	1600			
–	–	[illegible]	–	4988	–	225	3247			
15950	–	[illegible]	–	18356	–	4836	15737		196614 1 11	
–	–	[illegible]	–	3900	–	60	2500			
21880	–	[illegible]	–	10403	–	3224	6377			
–	–	[illegible]	–	[illegible]	–	1856	4926			
840106	–	[illegible]	–	73031	–	24935	73636			

APPENDIX

K

Reports on Dimāt and Bhosān Bridges,

[illegible] supply [illegible] would [illegible] than [illegible] that [illegible] may [illegible] the [illegible]

3rd [illegible] a supply [illegible] for the [illegible] from the [illegible] supply [illegible] for the [illegible] the [illegible] of the [illegible] that [illegible] the [illegible] the [illegible] to the [illegible] that [illegible] is [illegible].

4th [illegible] of the [illegible] from the [illegible] in the 17th [illegible] his attendance [illegible] in the [illegible] to [illegible] the [illegible] by [illegible] of [illegible].

[illegible] the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] [illegible] [illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] } [illegible] { [illegible] [illegible]
[illegible] [illegible] [illegible] } { [illegible] [illegible] [illegible]

[illegible]	[illegible]
1. Quality of material [illegible]	The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] × [illegible] × [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].
2. Quality [illegible] [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] the number of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible]

[illegible] the [illegible] the Committee although the [illegible] the [illegible]
[illegible] the timber [illegible]
[illegible] of the [illegible]. The Committee are of opinion that [illegible]
[illegible] that no other [illegible] have been [illegible] of the timber [illegible]
[illegible] the timber [illegible]
[illegible]
[illegible] of the [illegible]
[illegible] the [illegible]
[illegible] the work [illegible] of the [illegible]
Engineer of the 2^d [illegible], that [illegible] the
[illegible] when he [illegible] the [illegible]
[illegible] they [illegible] the [illegible]
[illegible] his [illegible] that [illegible]
[illegible] the Committee [illegible]
[illegible] that the [illegible]
[illegible]
[illegible] that the
[illegible] and he [illegible]
[illegible]
[illegible] the free use of water in keeping [illegible]
[illegible] probably the cause of the [illegible]
in the [illegible]. The Committee also [illegible] that
[illegible] and that the
[illegible] of the [illegible]
[illegible] have been [illegible] by the removal of the
[illegible] them, [illegible]
[illegible] the [illegible] of the [illegible]
[illegible] could have been [illegible]
[illegible] their [illegible]
[illegible] the [illegible] of the [illegible]

	The Committee [illegible] that [illegible] of the [illegible] of the [illegible] [illegible] that [illegible] was [illegible] perfect [illegible]. The [illegible] to the [illegible] [illegible] the Committee [illegible] that Officer has not been [illegible] the Committee [illegible] [illegible] [illegible]
Height of the walls of the compartments and of walls at point where [illegible] were struck?	[illegible] the [illegible] [illegible] the [illegible] [illegible] the [illegible] of the [illegible] [illegible] the [illegible] of the [illegible] and the [illegible] walls [illegible] [illegible] up 2 feet 2 inches higher.
State of [illegible] of [illegible] banks, how long the [illegible] had been allowed to stand before the [illegible] were built [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] struck?	[illegible] [illegible] about [illegible] days before the [illegible] were built. The [illegible] of the [illegible] [illegible] [illegible], [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] walls [illegible] to the [illegible] [illegible] the [illegible] of both [illegible] [illegible] [illegible] and the [illegible] and was [illegible] 6 inches [illegible] the [illegible] of the [illegible] [illegible] [illegible] of the [illegible] [illegible] of the [illegible] [illegible].
Position of [illegible] [illegible] [illegible] to the accident?	The appearance [illegible] [illegible] having occurred.
Whether [illegible] the [illegible] [illegible] [illegible] [illegible] neglect or carelessness on part of the Establishment [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] that [illegible] the [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] The [illegible] of [illegible] [illegible] [illegible] [illegible] of the [illegible]

of the [illegible] of the work, [illegible] [illegible] [illegible])	
7. The amount of supervision given to the Assistant Overseer in charge of the [illegible]	The Committee having, on the [illegible] [illegible] [illegible] in their opinion of the [illegible] [illegible] [illegible] the [illegible] of engaging the [illegible] Lieutenant E. Sharpe, regarding the amount of supervision bestowed on the works by himself, and [illegible] engaged Mr. O'Farrell, as assistant overseer of these Works, and they are specifically directed to this point, [illegible] consider this supervision, as regards the number of visits of Lieutenant Sharpe, and the constant attendance of Assistant O'Farrell, sufficient [illegible] [illegible] [illegible] expectation of good work.
	The Committee further examined, with [illegible] [illegible] to the [illegible] [illegible], which, having been [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible], that [illegible] [illegible], after a careful [illegible] examination, they think the [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] in the [illegible]. They therefore recommend that it be [illegible] [illegible] [illegible] without removing the [illegible] [illegible] any further, as permitting further [illegible] [illegible] of the cement, as the former operation [illegible] [illegible] in their opinion, [illegible] [illegible] and further setting of the mortar would [illegible] [illegible] the difficulties of [illegible] the [illegible], [illegible] and affording any [illegible] [illegible] of [illegible].
	The Committee have inspected the [illegible] [illegible] [illegible] bridges also, [illegible]
	[illegible]

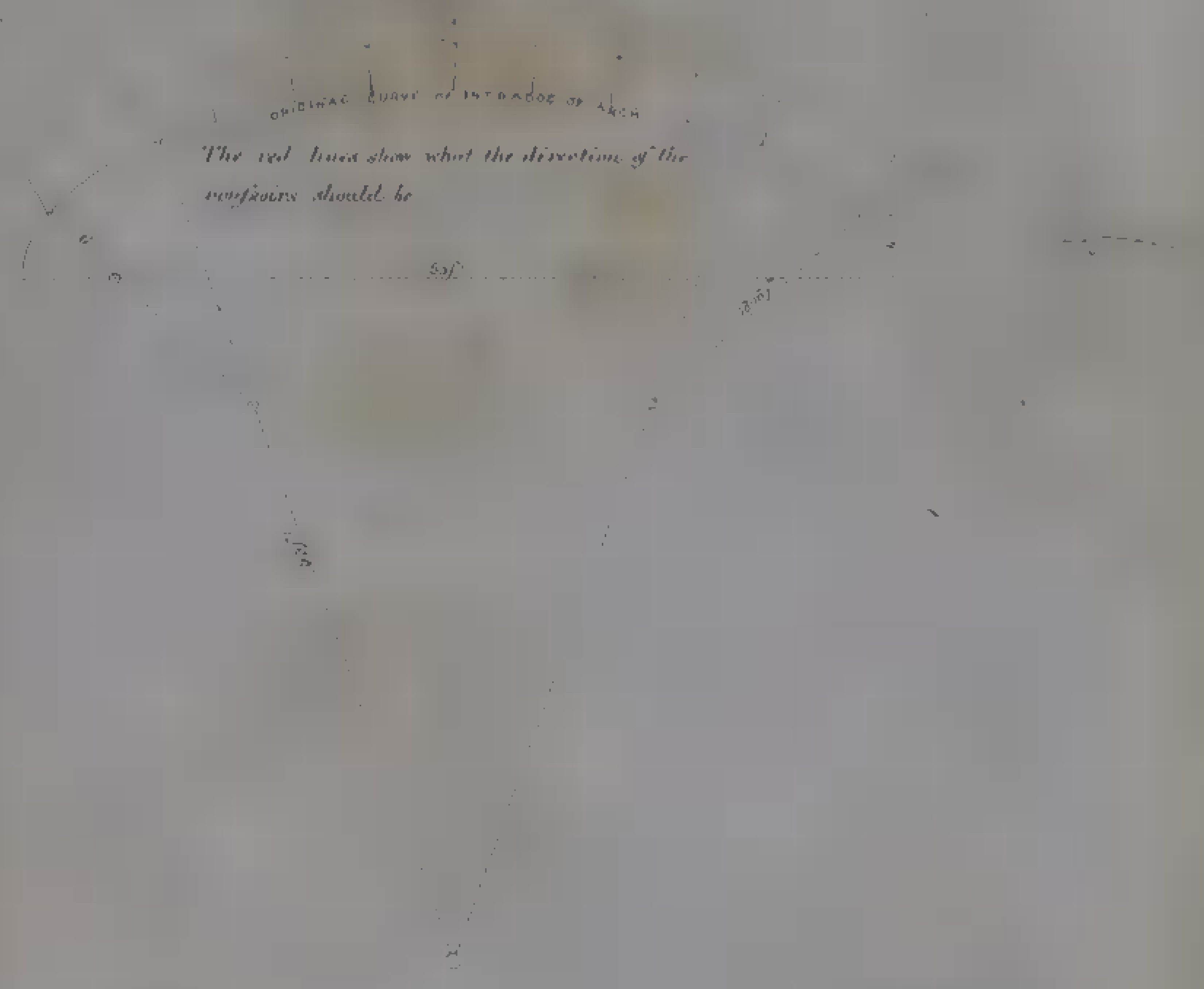
which they form [illegible]

(Signed) [illegible]
(Signed) [illegible]
(Signed) [illegible] Chief Engineer [illegible]

DIMAT BRIDGE

Eastern Arch

Showing direction of voussoirs at distances of 5 Feet measured from the centre



No. 209 of 1851/52

From,

Lieutenant C. W. Hutchinson
Ex. Engineer 6th Divn. Ganges Canal

To,

Lieutenant Colonel P. T. Cautley
Director Ganges Canal &c.
Camp Kuhon 23rd February 1852.

Sir,

I have the honor to report to you that a few days after the entire removal of the Centring (an Earthen one) of the Bhosan Arch it fell.

This Arch (and one of the Skewbacks) was built by contract by Mr. Hussey under the immediate Supervision of Mailwane, Sub Assistant Civil Engineer.

I attach a sketch of the state of progress in the adjoining side passages &c. and a dotted line shewing the position it assumed on falling.

The cause as it appeared to me of this accident, and as Lieutenant Humes (whom I sent for to meet me on the occasion of my visiting it after it fell) also thinks, was solely the very bad quality of the masonry in the backing to the Arch (built by Mr. Hussey) and in the great quantity of Mortar used, and in the very inferior quality of this Mortar.

This Skewback was the first masonry on the Bridge that was built by Mr. Hussey, the Abutment and the other Skewback were built previously by

Madhorām and are much better built.

Madhorām states that he was absent on other works for the two or three days during which this was built, and was not aware it was so bad, although he was aware of the inferior quality of the Mortar as he saw it used on his return in other parts of the Masonry, and at once insisted on its being properly prepared (it was not even ground or mixed in the Mill at first) and saw that better lime was supplied to Mr Hussey.—

When I first visited the work, to see the quality of Mr Hussey's Masonry, I thought it so bad, in the portion of the side passage walls that were built, that I had them pulled down, and particularly pointed out to Madhorām that he was to allow no such Masonry to pass. The Storback was covered over on the top and I did not observe that it was so bad.—

The Arch itself was very well built and the Mortar used in it is very good and the joints are fine.

The Storback lies now as shown in the sketch, thrust off the Abutment almost, and on examining it, the inside of it appeared to have been stuffed with Mortar, and this Mortar has no hold of the bricks whatever. The Mortar was all in powder. The arch therefore had nothing whatever to resist its thrust save a few bricks.

[Mr Hussey discontinued all Masonry work in the middle of January last, not finding sufficient profit in the rates I allowed him.— 24/?)

Having allowed him to carry on the arch and other Masonry work without having discovered the badness of the Storback built by him, I conceive that I cannot in any way now call upon him to rebuild

any

any part of the fallen masonry or even [illegible] fault with him.–

The total loss by this accident is about 230 Rupees, and this will not cause the Estimate for this Bridge to be exceeded; especially as so much masonry has been cut off by the omission of the Ogee walls.–

The skew backs are now being rebuilt and after they have had four months to consolidate the Arch will be again turned.–

I have &c

(Signed) R. W. Hutchinson Lieut.

in Charge of Division [illegible]

BHOSAN BRIDGE [redacted]CH

February 1852

APPENDIX
L

System of keeping accounts introduced into the Roorkee workshops, by Mr Harry Marten

Memorandum on an improved system for conducting and keeping the Accounts of the Roorkee Workshops.

The communications which have taken place between Colonel Cautley and myself, having ended by his deciding that the management and account keeping of the Roorkee workshops, on their becoming independent of any particular work, shall be made to correspond as nearly as possible with what would be the system were the Factory to be worked by a Private Company; and having been desired to draw up a memorandum on the plan which should be adopted for carrying out the object proposed, I beg leave to state that my General views regarding the Roorkee workshops are these:-

2. That they should be looked upon as, what they must ultimately become, a large Factory and General Furnishing Warehouse, whose objects are to manufacture and retail out, every description of Article required for Engineering purposes whether undertaken by the Government or by private individuals, and that in order to ensure these objects being gained, the Institution should be conducted on the principles which guide similar concerns, the property of private Companies - the only difference being, that a private company would work its Factory for pecuniary profit - the Roorkee workshops would be worked merely to cover their expenses.

3. The principal features involved in these views are:-

1st. That the Factory being conducted on the above principles - the Director of the Ganges Canal works should represent the Interests of its Proprietors (the Government of India) and the

vested with powers, and act in every way, as if he were "managing Director" (by which designation I shall hereafter refer to him) to a private Company;—

2nd That the Factory be made to pay all the expenses incurred upon it - except for the Cost of the original Buildings and motive power, upon which (they being held as "Dead Stock" the property of the Government) it should pay the usual 5 per Cent Interest only;—

3rdly That a Commercial system of Bookkeeping be introduced into the Office of the Factory;—

4thly That as the business of the Factory will embrace Sales to private Individuals, and the supplying of Government Officials, the system of payment should be the same in both cases.

4.— On the first point, there is hardly any necessity for my remarking upon the duties of the Managing Director;- he will of course watch with all possible vigilance the progress and growth of this promising Factory - Supply funds whenever necessary - Inspect the works and examine the Accounts - advise and Control the Superintendent in every possible way without harassing him with useless details - make reports to Government on what had been done and was doing - Submit such periodical Balance Sheets and Progress Reports as would satisfy the Government as to the working of the Concern &ca &ca; but in order that his Interest in the Welfare of the Factory may not flag, he should be vested with some amount of discretionary power.—

5. In elucidation of the 2nd point - I would refer to the Books of account appended to this paper, and to explanations of the same which will presently follow

follow under the title of "Instructions to Superintendent"
It will be seen that all expenses on -

Repairs of Buildings
Permanent or Superintending Establishment
Wear and tear of Tools
Interest on Dead Stock -

which is the extent of the contingent charges during the month fictitiously represented, are Debited to "Profit and Loss". To meet this amount a per centage which in the course of a few months may be very approximately estimated, on all manufactured Goods going out of the Warehouse, is charged, and the amount so realized credited to "Profit and Loss" thus the Factory not only exhibits itself as no expense to the Government, but returns a per cent on the value of its dead Stock - and, moreover, always distributes its working expenses amongst those who have the best right to bear them:- Viz: the purchasers of manufactured articles, whether private individuals, or Government Departments.

6. On the 3rd point also, the best illustration of the advantages of a good system of Book-keeping, that I can give, is the Books themselves, and the explanations before adverted to; but to make this paper complete, I must, as briefly as possible, refer to them here - The particular system which I have illustrated in the appended forms is that known as "Double Entry" and is the one always adopted when large Interests are at stake, and when a merchant is desirous of shewing good Books: it is accuracy itself, for no error can creep into the Accounts without being detected when the Balance Sheet is being made out. With a careful Book-keeper, the Superintendent is relieved of all anxiety on the score of his Accounts: every transaction to

being stamped in the Day book the moment it oc-cur's, the rest follow in succession, and with this surety, the Superintendent can devote the whole of his time to his legitimate duties. As explained in the instructions, the receipt or payment of money is confined entirely to the Office; nobody has the handling of money but the Cashier; and the subordinates of the Factory who incur expense either in labor or withdrawal of material from store, having each made up his portion of the Daily Abstract, are free of accounts. No delay, therefore, ought to oc-cur in the Books being kept up with regularity and expedition. One day's notice should be sufficient to produce a Balance sheet com-prehensively shewing the state of the affairs of the Factory on any given date. In addition the Government is assured as much as may be against fraud, for the Foremen, Overseers and Store-keepers having nothing to do with payments and the Cashier being able to disburse money only on the indelible authority stamped on the Daily Abstracts, no collusion could possibly exist without being detected by a watchful Manager. The "Instructions" provide fully for the Government and its Offices of account being satisfactorily accounted to for what in commercial phrase, may be styled the risk embarked in the Factory, while at the same time, from the compre-hensiveness of the system of Book-keeping, the Office work not only in the Factory, but in all the Offices of Control, is reduced to a minimum.—

7.— On the 4th point. My object is to secure the Factory from the introduction of varying principles in the conduct of its account, which would inevitably create confusion, and suggest excuses for arrears. As the sales to Private individuals must necessarily be cash

cash transactions. I would make this the guiding principle— and demand similar cash payments &c from the various Departments of Government that may purchase from the Factory— Although this is a mere question of principle, it has many advantages over the present course: for the Factory would be saved from submitting elaborately detailed bills twice over. (One to Government and one to Purchaser) and all the Correspondence requisite for getting Bills passed and their amounts debited to the various Departments and the Department supplied with articles having paid cash for them is certain to bring the transaction on its books: not only, therefore, does that particular Department become at once answerable for the cost of articles necessary to its operations, but the Head Offices of account are able to rapidly adjust the true value of the Government property in each of its departments, at least as far as transactions with this factory are concerned— The money obtained from these sources would often render the Factory independent of advances from Government and in this item also bear some measure of relief to its own and other offices of the State— The monthly account current which is to be submitted to the accountant then from the Factory would account for money so received. –

8. In the accompanying forms of Books and Statements I have endeavoured to provide for the general wants of the Factory and in proceeding now to explain them, I shall enter upon other topics which will not only tend to make the proposed system understood but be suggestive of the orders that may be necessary on the separation of the Factory from the Ganges Canal Works, as

Instructions to the Superintendent.—

9. The Managing Director has the General Control of all the Establishments attached to the Roorkee Factory and in him is vested authority for the appointment and dismissal of the permanent Establishment which comprises in addition to the Superintendent.

Deputy Superintendent
Foreman Engineer & Foreman
Overseers
Mistries
Draftsman
Storekeeper
Bookkeeper and clerks in the Office

and no appointment or dismissal can be made in any of these Grades without his sanction.

10. The Superintendent has the immediate and particular control of all the Establishments and of every department attached to the Factory and he has the arranging for, and disposing of Labour in such strength as the requirements of the work in progress or about to be put in progress, may call for.

11. The Superintendent's special duties are the general management. Seeking, selecting and purchasing material most adapted to the purposes of the Factory. Devising methods and ways for turning to the best use all the Motive power, Machinery, Establishments &c. that are at his disposal — introducing improvements into existing designs. Adapting simple machinery, calculated to come within the comprehension of the natives, to the purposes of more costly and intricate machinery &c &c. and, in fact, while exercising a wholesome check upon every body and every thing placed under him, to endeavour by every means in his power to promote progress, and successfully work out the object of the Founders of the Institution.

12. The Superintendent might place his Office under the immediate charge of the Deputy Superintendent as one of his duties; and as all moneys to be received are paid into the Treasury, he might accomplish this "Cash" by keeping the Cash Day Book (Form 1.).

13. At the working of the Factory it would be found convenient to keep the manufactured goods distinct from all other items and by having a Warehouseman (European Assistant Overseer) in charge of them and for receiving all orders that may be received. In the course of time, as the manufactured articles increase in extent and interest a Show Room might be erected, and the things so arranged, that visitors might at once see the quality and description of work the Factory was able to turn out. The Warehouseman should keep his account of Stock in hand and issues in a Tabular Form similar to that (Form 2) appended for the Storekeeper. So that the balance remaining in the Warehouse after each days orders had been executed, might be seen at once, but the remaining account of the "Receipts and Issues" of each day should be kept in the form 2a and 2b.

14. The Superintendent being the receiver of all orders, would make any remarks upon them that he considered necessary, and send them to the Office for entry into the Order Book (Form 3). This Order Book being sent to the Warehouseman, he would execute them to the extent his Stock admitted, and fill up the columns left in the book with information expected from him. With Goods despatched he would always send a "List of Stores despatched" (Form 4) and should the goods be going to a distance which

recovered.

rendered an advance of Cart hire necessary, he would note on this list the total amount of Cart hire to be paid the advance made by the Factory, and the Balance to be paid by the receiver of the Goods. The presentation of this list by the Chuprassy going in charge of the Stores, to the Cashier, would be sufficient warrant for his paying the amount indicated. The Invoice of such despatches would be made out from the Issue Book and sent off by post, after its contents had been copied into the Invoice Book (Form 5). Every manufactured article sent out of the Warehouse is to bear a percentage to cover the cost of the expenses of the Factory and this is added on in the office, the Warehouseman's rates being those for the cost of material and Labor only.

16. The Office attached to the Factory is to be formed and conducted on Commercial principles, and it is to be Comprehended every transaction Connected with the working of the Concern. nothing should go out of, or come into the Factory without passing through it, all money must be received into, and paid from, it; and with exception to muster rolls, (Form 8) and Stock registers, no accounts whatever are to be kept away from it. The Daily Abstract Book will be open in the Office, and such subordinates as have to account for Labor employed under them, Stores issued or received &c. will attend at the time that may be fixed upon for the purpose of entering into it the results of their days operations. I deem it proper to leave to the Superintendent, whose duty it is especially

especially in the fixing of each subordinates share in the filling up of this Daily Abstract - but my idea is, that a most excellent check might be established over this, the most important part of the Factory, by the Foremen and others having squads of workmen under them, being made to keep a memo of the people employed - the materials received from the Yard in each of their sections and when the general muster was about to enter the details under each head of work, that they should compare their memoranda with the return of the Musterer - the same with the store keepers; and attest the correctness of the entries by affixing each of their names to that portion which applies to their several sections. - This Daily Abstract would form one of the most important of the auxiliary books required. the form already in use in the shops (Form No: 41) is probably as good a one as can be devised - and the only addition wanted is a general Abstract to be made up by the Book Keeper, in which he should extract the rate for each article manufactured and transferred to the Warehouseman's books generally. this would be made up at the end of every month for posting to the principal books, but if the article completed was to be sent away immediately, the Abstract could at once be made out. The other auxiliary books are the Cash Day Book, and the Stock Books for which forms are given, and which require no explanation - their purposes being plainly stamped on their pages.

16. The principal books are the Day Book, Journal and Ledger; these are to be kept on the

system known as "Double Entry" the grand objects being, to secure to the Factory a faithful record of its transactions (with the least amount of labor, and to show that the Factory pays the whole of its expenses, and returns to the Government 5 per cent Interest on its outlay in buildings and Motive power. In drawing up the forms of these books, I have supposed that the Superintendent has just received independent charge of the Factory; that he has taken over from Lieutt Goodwyn the whole of the Dead Stock, Machinery, Tools, Raw Material and manufactured Goods that exist on the date of the Transfer and that he, subsequently receives an advance of money from the Managing Director. By the first account in the Ledger, "The Government of India" I prove that it gets the Credit for these as well as for the Interest on its Dead Stock, and by the last account "The Balance Sheet" that the Credit so given is the actual Capital of the Factory, and that the books are Correct.

17. The Day Book and Journal are kept in one book: the former occupying the left page, the latter the right one, and much time and trouble are saved by this arrangement, besides the surety of accuracy. for if the entries in the Journal (which is the Index to the Ledger) are correct, the Totals of both its columns must agree and also correspond with the total of the Day Book column. In the Day Book we commence with an entry representing the value of the Stock which we have to work upon then follows the incomings and outgoings as they

occur

occur, and on the last day of the month we bring forward in abstract the data afforded by the "Daily Abstract" in the expense that has been incurred in manufacturing and the months transactions are closed by the entries of all the contingent expenses of the Month.

18 The Journal is ordered from the Day book and shews how the transactions are to be posted to the Ledger. Each Day Book entry calls for one Dr and one Cr in transferring it to the Journal, for the principle is that the Drs must be equal to the Crs and therefore the first item in the Day Book is transferred to the Journal as "Stock Dr to Factory Buildings &c" and Cr to the Government of India" whose property it is. the next entry in the Day Book is a Draft which it is not convenient to Cash at once it is consequently "Dr to Bills receivable" and "Cr to the Government of India" and when the cashing of the Draft does take place it is "Dr to Cash" and "Cr to Bills receivable" the succeeding item "sale of manufactured Goods" is Dr to Sundry "Creditors" the purchaser, and "Cr" partly to "Manufactured Goods" and partly to "Profit and Loss" the latter amount being the sum charged for Factory percentage beyond the actual cost of the article, and which is set off to the Contingent charges of Supervising Establishment, percentage for wear and tear of Tools, and Interest on Dead Stock which are all "Dr to Profit and Loss" the red figures are the folios of the Ledger to which the items are posted.—

19. The Ledger is the chief of all the Books; a reference to it shews the exact state of each account—

and

as also of the affairs of the Concern for which it is Kept. a Balance sheet drawn up from it, at any time that may be required determining at once whether the Factory is going on well or otherwise. In the Book that I have prepared, the entries in the journal before described, are all posted to their separate accounts, and by following them out it will be easy to understand how the Balance Sheet tests the correctness of all the accounts that have gone before it. - I have only further to remark on this Book that I have judged it proper that the Profit and Loss account of the Roorkee Factory should admit on its Dr. side only those Contingent Charges of its Establishment, Repairs of Buildings, &c. which the purchasers of Manufactured Goods have a right to pay, and on its Credit side the sums realized by the percentage charged upon such goods; and that the value of the labor performed by Steam Engines after deducting the expense of working them, should instead of going to the Cr. of Profit and Loss form a fund either to decrease the amount value of Dead Stock or to meet any unforeseen accident that may occur. this idea having been carried out in these accounts, we find that after accounting to Government for all that is its due, there is a sum of Rupees 2590/-/- still to be worked off by the charge of Factory percentage on Manufactured Goods; the value of the stock of Manufactured Goods is 16,750 Rupees. - the 10 per cent which has been assumed for the month illustrated, upon this sum is not enough therefore to cover the Balance at

Debit

debit of Profit and Loss and during the subsequent month the Factory percentage charge must be raised to 15 per cent. accordingly as each months Balance of Profit and Loss is exhibited with reference to the value of the Stock of manufactured Goods, so must the Factory percentage be raised or decreased. As the charge for Establishment, repairs, Interest &c is nearly a constant quantity, the percentage fluctuates according to the work done, and the Superintendent will therefore see that the more work he executes the lower will be the rate for Factory percentage, and consequently, the greater the credit due to his management. On the Steam Engine working account we see that there is a fund of Rupees 2,400 to meet any accidents or for appropriation as may be decided upon.

20. The Balances should be struck every month the value of Stock in hand being taken from the accounts. At the close of each year, it would be a safeguard that the Balances of Stock should be corrected by an Inventory of every thing being taken.

21. The Book-keeper attached to the Factory will understand that he is responsible for the correctness of the Books and for their being brought up with regularity. If, at the Managing Director's Inspections this is found not to be the case, the Book Keeper alone will bear the censure.

22. Every manufactured article sent out of the Factory is to be paid for by the purchaser whether private individual, or Government official, and the amount so realized carried to the Cr of the Factory by Cash being made Dr. When other money is required for the purposes of the Factory application is to be made to the Managing Director.

23. The Superintendent will submit to the Managing Director as soon as each months accounts are closed. :—

1. Copy of the Ledger account with the Government of India.—
2. Copy of the Ledger Balance sheet
3. Account Current (Form 6)
4. Copy of the Ledger Cash Account
5. Copy of the Abstract of the Daily Abstract
6. Progress Reports
7. Acquittance Rolls for Salaries.—

Nos. 1. 2. 3 and 6 will be forwarded by the Managing Director to the Military Board for their and the Governments information; No. 3 will also be sent to the Accountant accompanied by the Acquittance Roll.— Nos. 4 and 5 will be retained in the Managing Directors Office, and will be his Checks upon the Factory.—

24. The papers above indicated as having to be submitted to the Board will render every information to the Government that could possibly be desired.— No: 3. from being in detail as regards the debits which are due to other Departments for the purchase of manufactured Goods, will place in the hands of the Board and Accountant, the means of checking the Charges brought forward in those Departments.

25. Changes in old established Customs— no matter how beneficial they may profess to be are generally looked upon with suspicion; and, at first sight, it may be thought that in the proposals I have made there is an attempt to separate this particular Institution from the connection and control which the Government

now

now exercises over its several departments. I would however, disclaim any such intention, and urge that the only object I have, and I trust that the preceding pages have proved it, is to introduce into this Embryo Factory and General Furnishing Ware-house sounder systems of account keeping, by which it shall have every encouragement to proceed on and arrive at that state of usefulness which is contemplated by its Founders; and at the same time protect the Interests of the Government immeasureably better than the present imperfect system admits of.—

June 1832. (Sd) Harry Marten
Assistant

(Form 1) –

Form of Cash Day Book

Date	Description	Folio	Expenditure	Receipts
15	Received from the Collector of Saharunpoor, cash in lieu of Director's Draft No. 1 of 1852/53	1	" " "	10,000 " "
20	Paid to the Monkland Iron and Steel Company for Iron	1	5000 " "	
25	Received from Nynital for Goods	1	" " "	110 " "
31	Paid Labor for May 1853	1	3590 " "	
	Paid Permanent Establishment for May 1852	1	1000 " "	
	Total		9590 " "	10,110 " "
31	Cash Balance in hand		520 " "	
	Total Comp. Rupees		10,110	10110 " "
1	Cash in hand	..	" "	520 " "

Form 2

Store Keepers account of Receipts and

Date	From whom received or to whom issued	Bar Rolled Iron 1½ inch	Bar Rolled Iron 1¼ inch	Bar Rolled Iron 3 inches	Bolt Iron 7/8 inch	Bolt Iron 1 inch	Angle Iron 1¼ x 7/8	Angle Iron 1½ x 7/8	Rolled Iron 4 inches
1852		Mds	Mds	Mds	Mds	Mds	Mds	Mds	Mds
May 1st	From H. Goodwyn	100	100	100	400	600	600	400	
10	To Mr. ____ Foreman	50	"	50	"	100	-	-	
	10th May Balance	50	100	50	[illegible]	400	500	[illegible]	
20	From Monklans Company	500	-	-	-	-	-		500
	20th May Balance	550	100	50	400	400	[illegible]	400	500
31	To Mr. ____ Foreman	50	50	30		.	-	50	100
"	To Mr. ____ Foreman	50	25	10	100	[illegible]	-	-	-
		100	75	40	100	300	-	50	100
	31st May Balance	450	25	10	100	100	500	350	400

Iron

(Form 2)

Form of Order Book

Description of Articles	by whom to go	Columns to be filled up by warehouseman: Rate	Customary	Total	Incidental	[illegible]

No. 2A

The Columns for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance. All advances to Customers being made would appear here and be duly included in the Bill submitted to the purchaser. The attached Form for the warehouseman's "List of Stores despatched" will make this plain.

[illegible] Book of Receipts

Date	Description	No.	Quantity mds. seers ch.	Rate	Amount Rs. as. p.	Whence received	Re[illegible]
1853							
November 5	Tallow	„	20 „ „	8/	160 „ „	Butcher	
	Coal Baskets	1000	„ „ „	1/19	52 10 1	Bhowani Contractor	
	Mattie do	500	„ „ „	5/1/4	8 12 11		
	Iron Slabbes [illegible]	„	50 „ „			Delhie Magazine	
	Old Copper cuttings	„	„ 10 8			Shops	
	Old Steel files	„	„ 14 4			do	
	Bolts 1st Class	200	13 8 10			do	
	Brass borings and filings	„	„ 4 14			do	
	Railway truck [illegible]	40	„ „ „			Ex Engineer	
	Wrought Iron 1st Class	„	2 4 „				
	do do 2nd	„	4 9 7				
	do do 3rd	„	15 4 4			[illegible]	
	[illegible] 2nd Class	„	„ 24 „				
	[illegible]	„	„ 32 „				

(Form 3)

Form of Order Book

Description of Articles	by whom required	Columns to be filled up by Warehouseman: Rate	customary	No. of	total	Incidental	when issued & amt. & dated

(Form C) Book of Issues

	No. of Book	Description	No.	Quantity	Remarks
5	28	Plummet Blades	40	1 2 3	Making up
	28	— do — Sockets	40	„ 10 „	Making up
	28	2nd Class Nuts	„	„ 1 4	Making up
	32	Leather Buckets	40	„ „ „	Co. Engineer
	32	Country Twine	„	„ 10 „	— do —
	do	2nd Class	„	„ 2 „	Mr Logan
	„	Putty	„	„ 4 „	Mr Brown
	2	Old Copper	„	„ 4 „	Brass furnace
	2	Zinc	„	„ 1 „	Brass furnace
	1	Old Iron pieces	„	2 2 6	
	1	Iron flat bar	„	1 17 3	Forges
	1	— do — Square	„	„ 24 2	Forges
	1	— do — Rod	„	3 10 4	Forges
	1	— do — Hoops	„	„ 49 „	Forges
	1	Shear Steel	„	„ 1 8	Forges
	1	Cast Steel	„	„ 2	Forges

The Column for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance. All advances to Customers being made would appear here and be duly included in the Bill submitted to the purchaser. The attached Form for the Warehouseman's "List of Stores despatched" will make this plain.

[illegible] 2 B

/ Form 2 /

Form of Order Book

Description of Articles by whom required and date of Order	Columns to be filled up by Warehouseman: Rate customary or warehouse [illegible]	Date of Despatch	Incidental Expenses &c.	[illegible]
10th May 1852				
Lieut. A. G. Goodwyn Ex. Engr.				
Wm. 10th Gauges [illegible] as per letter No 5 of this date:—				
40 Side Tilt Wagons complete	100	[illegible]		
10 Brick Making Machines				
10 Pile Engines.				
25th May 1852				
Nyohal Carpenter – for ready money				
Carpenter's Chest of Tools	100	May 25		25th May 1852
31st May 1852				
Workshops:				
1 Carpenter's Chest of Tools	100	May 31		31st May 1852
1 Smiths' Do	50	[illegible]		

The Column for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance— All advances to Cart-men being made would appear here and be duly included in the Bill submitted to the purchaser— The attached Form for the Warehouseman's "List of Stores despatched" will make this plain.

1st Form 4

List of Stores dispatched to Colonel
per Civil Engineer, Punjaub, in part of his
dated 4th July 1852

Roorkee Workshops 5th July 1852

Bholer Bux, Chuprassy in Charge.

Jhams for Block-sinking	50
Windlasses for Do	50
Phurras without handles	100
Brick making Machine	1

2 Four bullock Carts engaged to deliver the above articles at Lahore for Rs 30.0.0
Advanced by Roorkee Workshops Rs 5.0.0
Balance due to be paid by Col. Napier — 25.0.0

A.B.
Warehouseman.

(Form 5)

Form of Invoice Book

	Rate	Amount	Total
1 Lieutenant Goodwyn, Executive Engineer, Northern Division Ganges Canal.			
40 Side Tilt Ballast Wagons complete with &c &c ——— @ ——	100 " "	4,000 " "	
Add Factory percentage @ 10 per cent ——		400 " "	
Grand total Company's Rupees ——			4,400 " "
1 Mychal, Carpenter, for Cash —			
1 Chest of Carpenter's Tools —— @ ——	100 " "	100 " "	
Add Factory percentage @ 10 per cent ——		10 " "	
Grand total Company's Rupees ——			110 " "
1 Factory.			
1 Chest of Carpenter's Tools —— @ @	100 " "	100 "	
1 do Smith's —— do —— @ @	50 " "	50 " "	150 " "

Jan. 6.

4

Dr. — [illegible] — For [illegible]

18[illegible]

[illegible] 1 [illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	36,000.0.0	[illegible]	
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]
[illegible]			[illegible]

Total [illegible] — [illegible]

Cr. — Acc[illegible]

18[illegible]

May 21 [illegible]			1,00[illegible]
[illegible]			
[illegible]		110	
[illegible]			
[illegible]			
[illegible]	150.0.0		
[illegible]	11000.0.0		
[illegible]	5,000.0.0	16,150	
[illegible]			
[illegible]	1000.0.0		
[illegible]	1000.0.0		
[illegible]	500.0.0		
[illegible]	500.0.0	5,000	
[illegible]			
[illegible]		3,500	[illegible]

Total [illegible] — 1,5[illegible]

May 185[illegible]

Account Current with the [illegible] Company — Cr.

2 By Balance [illegible] of [illegible]
Cash [illegible] due as cash — 141,3[illegible]

Total [illegible] — 1[illegible],300

[illegible]tory — Cr.

[illegible] By [illegible]			
[illegible]			
[illegible]	4,000		
[illegible]	400		
Brought — [illegible]	4,400		
[illegible]	1,000	3,400	
By [illegible]			
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	
By Cash Account —			
[illegible]	[illegible]		
[illegible] during the month	[illegible]		
[illegible]	[illegible]	[illegible]	
By [illegible]			
[illegible]		[illegible]	
By [illegible] —			
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	2,400		
[illegible]	[illegible]		
Balance [illegible]			
[illegible]	2,590		
Brought — Total	142,900		
Balance [illegible]	2,400	140,300	

Total [illegible] — 163,[illegible]00

Daily Account of Work done in the Wa[illegible]

#1 Wrought Iron Work

Description	Total Labor / Material	Rate	Amount	Total
[illegible] mill	11,507	1/2	1333 3 6	
Iron Square	92,22,10	[illegible]	131 5 10	
" Rod	66,1,1	6/-/-	396 10 4	
" Flat	59,22,14	6/-/-	285 13 6	
" Sheet	7,36,0	9/-/-	63 3 9	
" Mounting	10,18,0	4/4/-	44 6 4	
" Wire	2,15,0	7/-/-	16 10 -	
Fit bolts	0,17,6	16/10/8	7 4 5	
Squares	0,26,0	5/[illegible]/-	3 9 2	
Lamp [illegible]	176	15/-	33 - -	
Charcoal	1810,0,0	-/6/-	603 12 -	
				1322 [illegible]

Day										
1	816	1/24/-	1/14/-	1/14/-	-/23/-	1/13/-	-/12/-			70/-/-
2	823	1/39/-	2/7/-	-/16/-	1/-/-	1/3/-	-/7/8			71/-/-
3										
4	746		-/7/-	-/3/8	1/2/-			-/2/8		70/-/-
5	774	4/9/-	10/-/-	4/22/-		1/35/-	-/10/-			
6	822	1/33/-	2/26/8	1/27/-	58/-	1/18/-	-/7/-	-/3/-		100/-/-
7	828									
8										
9										
10										200/-/-
11	834	3/13/-	4/26/-	6/31/-	1/33/-	1/2/-	-/18/-		-/26/-	
12	691	2/13/-	14/8/-	1/26/-	-/34/-		-/13/-			
13	802	1/6/-	3/7/-	-/35/-	-/26/-	-/20/-	-/6/-			400/-/-
14	777	-/39/-	2/9/-	2/2/8	-/26/-	-/6/-				
15	731	-/21/-	-/14/-	-/2/8	-/6/-	-/16/-	-/7/8			
16	583	-/29/-	3/20/-	6/32/-	-/14/-		-/10/-			
17		-/32/-								
18	564	-/2/-	2/27/-	-/37/-		1/2/-				200/-/-
19	330		-/31/-	-/11/-		-/3/-		-/1/-		
20	590		-/4/8							
21	296	-/35/-								
22	564		1/17/-	5/30/-		-/9/-				
23	30							-/3/-		200/-/-
24										
25	158	-/18/-								
26	507		2/2/-	-/4/-			-/7/-			
27	469	-/38/-	-/27/-		-/5/-	-/6/-		-/4/-		300/-/-
28	358	-/3/-	1/7/8	1/1/8						
29	474		3/24/12	-/20/12						
30	511		-/27/-	-/33/8						
31										

…during the month of June 1853.

No. 3 …

Day				
1	21			4/4/
2	21			
3				
4	21			
5	21			
6			1/12	
7	16			
8				
9				
10				
11		10		7/3/
12		10	16	
13		10		
14		10		
15		10		
16		10	12	
17				
18	21			
19	21			
20	21			
21	10			
22	21			
23				
24				
25				
26				
27				
28				
29				
30				
31				

Day Book
and
Journal

Day Book

Date	Description		Amount
1852 May 1	Stock as received from Lieut. Goodwyn		
	Value of Factory Buildings Stock Book page 1	50,000 " "	
	— Do — Steam machinery — do — 2	30,000 " "	
	— Do — Machinery and Tools — do — 3	20,000 " "	
	— Do — Iron in store — do — 4	10,000 " "	
	— Do — Timber in store — do — 5	10,000 " "	
	— Do — Manufactured Warehouse Goods — do — 6	10,000 " "	1,30,000
5	Received from Director of the Works Draft on Saharunpoor Treasury at sight No 1 of 1852/53 of 3rd current		10,000
10	Sold to Lieutenant Goodwyn Ex. Eng. 1st Div. Ganges Canal		
	40 side tilt Wagons complete — @ 100/- each	4,000 " "	
	Percentage of wear and tear Do — @ 10/- per cent	400 " "	4,400
12	Cashed the Directors Draft No 1 of 1852/53		10,000
20	Bought from the Monkland Iron Company for Cash 1000 Mds Bar iron (various) — Stock Book Page 1 @ 5/- per Md.		5,000
25	Sold for Cash, to Aydool, a Carpenter's Chest of Tools	100 " "	
	Percentage — @ 10/- per cent	10 " "	110
31	Lieut. Goodwyn's bill to Current repairs to Buildings		1,000
	Received from the Warehouse for the use of the Shops		
	1 Carpenter's Chest of Tools	100 " "	
	1 Smith's — do	50 " "	150
	Expenses during the Month as per Abstract Book		
	10 Brick making Machines completed and sent to Warehouse		
	Iron	2,000 " "	
	Timber	1,000 " "	
	Manual labor	3,000 " "	
	Steam Engine do	2,000 " "	8,000
	10 Pile Engines in progress		
	Iron	1,000 " "	
	Timber	1,000 " "	
	Manual labor	500 " "	
	Steam Engine labor	500 " "	3,000
	Cost of Repairs and working Steam Engine		
	Labor	90 " "	
	Iron	10 " "	100
	Cost of labor during May 1852 as per pay Book		3,590
	Cost of Permanent Establishment for May as per pay book		1,000
	Percentage for wear and tear of Tools @ per cent		500
	Interest on value of Dead Stock @ 5 per cent		500
			1,77,350

Journal

Dr.		Cr.		Folio of Ledger
80,000	Dead Stock			
20,000	Machinery and Tools			
20,000	Raw Materials	Government of India	130000	1
10,000	Manufactured Goods			
10,000	Bills Receivable	Government of India	10,000	1
		Manufactured Goods	4,000	3
4,400	Heath Goodeye	Profit and Loss	400	
10,000	Cash	Bills Receivable	10,000	
5,000	Raw Material	Cash	5,000	
		Manufactured Goods	100	
110	Cash	Profit and Loss	10	
1,000	Profit and Loss	Heath Goodeye	1000	
150	Machinery and Tools	Manufactured Goods	150	3
		Raw material account	5,000	2
8,000	Manufactured Goods	Labor	2,000	
		Steam Engine Working	1,000	5
		Raw material account	2,000	2
3,000	Manufactured Goods	Labor	500	
		Steam Engine Working	500	5
		Labor Account	90	
100	Steam Engine Working account	[illegible]	10	
3,590	Labor Account	Cash	3,590	
1,000	Profit and Loss	Cash	1,000	
500	Profit and Loss	Machinery and tools account	500	
500	Profit and Loss	Government of India	500	1
1[illegible]50			1[illegible]50	

Ledger.

Dr. — The Government of India — Cr.

Date			Fol.	Amount	Date			Fol.	Amount
1852					1852				
May	31	To Balance	6	140,500 ..	May	1	By Stock	1	130,0[illegible]
						5	— Cash	1	10,00[illegible]
						31	— Interest on Govt. Stock	1	[illegible]
		Total		140,500 ..			Total		140,5[illegible]
					June	1	By Balance		140,500

Dr. — Dead Stock — Cr.

Date			Fol.	Amount	Date			Fol.	Amount
1852					1852				
May	1	To value of	1	[illegible] ..	May	31	By Balance	6	[illegible]
June	1	To Balance		[illegible] ..					

Machinery and Tools — Cr.

	Fol.	Amount	Date		Fol.	Amount
			1882			
To value of	1	20,000	May 21	By Profit and Loss	1	500
" " do	1	150		" Balance	6	19,650
Total		20,150		Total		20,150
To Balance		19,650				

Raw Material — Cr.

	Fol.	Amount	Date		Fol.	Amount
			1882			
To value of	1	20,000	May 21	By Manufactured goods	1	3,000
" purchase machinery	1	6,000		" do	1	2,000
				" Loss in Steam Engine	1	10
				" Balance	6	19,990
Total		25,000		Total		25,000
To Balance		19,990				

Dr. — Manufactured Goods — Cr.

Date			Fo.	Amount	Date			Fo.	Amount
1852					1852				
Mar.	1	To Stock [illegible]	1	10,000	May	10	By [illegible]	1	400[illegible]
		" Co. [illegible]	1	2,000		25	" do. [illegible]	1	10[illegible]
		" do. — do.	1	3,000		31	" do. [illegible]	1	12[illegible]
							" Balance	6	16,7[illegible]
		Total		15,000			Total		[illegible]
June	1	To Balance		16,750					

Dr. — Bills Receivable — Cr.

Date			Fo.	Amount	Date			Fo.	Amount
1852					1852				
Mar.	5	To [illegible]	1	10,000	May	10	By Cash	1	10,000

[illegible] Goodwin & Co. [illegible] Cr.

	Fol.	Amount	Date		Fol.	Amount
To [illegible]	1	4,400 ..	180[illegible] May 21	By [illegible]	1	1000 ..
				" Balance	6	3,400 ..
Total		4400 ..		Total		4400 ..
To Balance		3,400 ..				

Cash Cr.

	Fol.	Amount	Date		Fol.	Amount
To Cash [illegible]	1	10,000 ..	180[illegible] May 20	By [illegible]	1	5,000 ..
" do [illegible]	1	110 ..	21	" [illegible]	1	3,590 ..
				" [illegible]	1	1,000 ..
				" Balance	6	520 ..
Total		10110 ..		Total		10,110 ..
To Balance		520 ..				

Dr. — Profit and Loss — Cr.

Date			Folio	Amount	Date			Folio	Amount
18[illegible]					18[illegible]				
May	21	To [illegible]	1	1,000 "	May	10	By Manufactured Cost	1	4[illegible]
"		" [illegible]	1	1,000 "	"		" [illegible]	1	[illegible]
		" [illegible]	1	500 "			" Balance	6	[illegible]
		" [illegible]	1	500 "					
		Total		3,000 "			Total		3,000
June	1	To Balance		[illegible]					

Dr. — Steam Engine (Working Account) — Cr.

Date			Folio	Amount	Date			Folio	Amount
18[illegible]					18[illegible]				
May	21	To [illegible]	1	100	May	21	By Manufactured Cost	1	[illegible]
		" Balance		4,400 "			" Do.	1	[illegible]
		Total		4,500 "			Total		[illegible]
					June	1	By Balance		4,[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Sales Account

Dr.			Cr.		
To Cash	1	3090	May 2 By Knitting machines	1	3000
			— Knit Goods	1	500
			— Raw Grain	1	90
Total		3090	Total		3590

Balance Sheet

Dr.			Cr.		
To Mine Stock	1	80,000	May 21 By Capital ...		
Sales & Machinery & Tools	2	19,650	...	6	9,400
— do Raw materials	2	14,990			
— do Manufactured Goods	3	16,700	By Balance being		
Cash from ...	4	3,400	net Capital	1	140,500
Cash in hand	4	520			
Profit and Loss	5	2590			
Total am't		149,900	Total am't		149,900

No. 46. — November 1833

Whellbarrows for Lieutenant Wyat

...luded	No. do	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
...dau —	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	9	·	9	9	9	"	225
... p/ —	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
... —	9/	·	9	"	9	9	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	9	9	9	"	9	9	9	·	81
—	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
...u [s]/ —	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	[illegible]	[illegible]	9	·	9	9	9	·	225
...dau [a]/ —	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
—	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
—	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
...a —	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
...er —	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
—	9/	·	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	9	9	9	·	9	9	9	·	225
...homa —	9/	·	9	9	9	9	·	9	9	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	54
Total —		·	108	[illegible]	[illegible]	[illegible]	·	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·	[illegible]	[illegible]	[illegible]		[illegible]

C

Tom. 8.

Stock Book.

Dead Stock the Prop[illegible]

Buildings

Interest at [illegible] of 5 per cent [illegible] the Governm[illegible]

1st May, 1852.

(To be detailed in such manner that the description of Land, number, & measurements &c may at any time be known)

50,000 . . 31st May 1852 3[illegible]

It will be understood notes without regard [illegible] of the Day Book. for this is only [illegible] reason of original [illegible]

Government of India Kurkee Factory

Steam Engines. 1st May 1852			Interest at the rate of 5 per cent credited to Government.	
be detailed in such manner that principal parts may be recognized	30,000 " "	31st May 1852	900 " "	

dates and amounts of Interest ... ary - and only to preserve the ... n also may be inferred upon ... ation of what is required to pay the

Cr. Machinery Acc

Date	Description	Amount	Po
1852 May	1 Received from Lt. A. C. Goodwyn Ex: Eng: N: W: Ganges Canal		
	1 - 5 inch Centre Holtzappfells Lathe &c. &c.	2,000 " "	
	2 — do — do — &c. &c. — @ 2,000/ —	4,000 " "	
	Punching and Shearing Machine	1,000	
	50 Anvils — @ 20/ —	1,000 " "	
	50 Carpenters Chests of Tools — @ 100/ —	5,000 " "	
	50 Smiths — do — @ 50/ —	2,500 " "	
	50 Forge Bellows — @ 10/ —	500 " "	
	500 — do — Hammers — @ 2/ —	1,000 " "	
	100 Dozen Files as below — @ 5/ —	500 " "	
	25 Doz: Smooth Round 8 in —		
	25 — " — Rasp — " — 8 in		
	25 — " — " — Bottom 8 in		
	25 — " — " — Safe edge 10 in		
	500 Smiths Beck Irons — @ 2/ —	1,000 " "	
	Screw Augers as below —		
	2 Doz: Long Sams with eyes ½ @ 20/. 40 " 0 " 0		
	2 — " — " — ¾ @ 25/. 50 " 0 " 0		
	2 — " — " — 1 @ 30/. 60 " 0 " 0		
	5 — " — " — 1¼ @ 40/. 200 " 0 " 0		
	4 — " — " — 1½ @ 60/. 200 " 0 " 0	550 " "	
	50 Hand Vices — @ 5/ —	250 " "	
	50 Best Turkey Stones — @ 10/ —	500 " "	
	1 Grindstone —	200 " "	20,000
May	31 Received from Warehouse —		
	1 Carpenters Chest of Tools —	100 " "	
	1 Smiths — do —	50 " "	150
	Total Company's Rupees —		20,150
1852 June	1 To Balance —		19,650

…Appen Cans used in the Factory — Cr.

Date	Description	Amount	Total
…82			
May 31	By percentage of wear and tear charged to Profit and Loss		500 " "
"	By Balance		19,650 " "
	Total Cons. Report		20,150 " "

N.B. This account Cannot is for the Office. The Store Keeper would keep his Stock in a Tabular form — making the authorized person in the Office his initials to any thing written off that may have been condemned as unserviceable —

Dr. Iron

Date	Description	Amount	Total
1882			
May 1	Received from G. A. C. Goodwyn		
	Ex. Engr. N. Divn. Ganges Canal		
	100 Bars Rolled Iron 1½ in. 400.0.0		
	100 — " — " — 1¾ — 100.0.0		
	100 — " — " — 3 — 400.0.0		
	200 Bolts — " — 7/8 — 400.0.0		
	500 — " — " — 1 — 500.0.0		
	500 Bars Angle Iron 1×⅝ 500.0.0		
	400 — " — " — 1½×7/16 400.0.0		
	Total Mds — 2,000.0.0 @ 5/- p. Md	10,000 " "	10000
21	Bought from the Monkland Iron and Steel Company as per Invoice of this date —		
	600 Bars Rolled Iron 1½ 500.0.0		
	500 — " — " — 2 600.0.0		
	Total Mds — 1000.0.0 @ 5/- p. Md	5,000 " "	5000
	Total Company's Rupees		15000
June 1	To Balance		11,999

Detail of Stock to be given with totals.

ccount — Cr

Date		Description	Amount	Total
1832				
May	31	Issued to Works during the month as per daily Abstract and as per Store Keepers account		3010 " "
		By Balance		11,990 " "
		Total Company Rupees		15,000 " "

Here again this account is merely for the Office - The Store Keeper must keep his in a Tabular form with all details - form for this is appended - and the same form will answer for all the Store Keepers, if there are more than one -

Dr. ———— Tim[...]

Date		Description	Amount	Total
1852 May	1	Received from Lieut. Alf Goodwyn Ex. Eng.: Mr. [illegible]		
		Detail [illegible] as in [illegible] account		10,00[0]
		Total Company's Rupees		10,00[0]
1852 June	1	To Balance		[illegible],00[0]
		Detail		

Account — Cr.

Date		Description	Amount	Total
1852				
May	31	Issued to works as per daily abstract and as per Store Keepers account		2,000 " "
		By Balance		8,000 " "
		Total Company Rupees		10,000 " "

See remarks to Iron account

Dr. Manufacture

Date	Description	Amount	Total
1832 May	1 Received from Lt. Atgood wyn Ex. Eng. Wr. Dr. Ganges Canal		
	(Detail articles as in Iron Account.)		10,000
May	31 10 Brick making machines @ 800/@	8,000 " "	
	10 Pile Engines in progress	3,000 " "	11,000
	Total Company Rupees		21,000
1832 June	1 To Balance	16,760 " "	

...oods Account Cr.

Date	Description	Amount	Total
18..			
May 10	By Sales to Lt. Goodwyn	4,000 " "	
	" " to Mychal Carpenter	100 " "	
	" issues to Workshops	150 " "	4,250 " "
	By Balance		16,750 " "
	Total Company Rupees		21,000 " "

The warehouseman should also keep his own account in a Tabular form so that on the receipt of orders he can at once tell by reference to it whether he has the articles in store or not.

APPENDIX

M

Sig 2 h

Appendise Ganges Cana
Sig H H-2
Vol IIA

List of Books belonging to the Council ... Library on the 1st of ... 18..

Names of Books	No. of Vols.	Size
...Bate...	1	8vo.
...Steam Engine	2	do.
...Astronomical Essays	1	do.
...ing on Boilers	1	do.
...Ganot's Physics (...)	2	do.
...Manual of Scientific ...	1	do.
...Orders 1862-63	1	4to.
...Magazine of Natural History	6	8vo.
...	1	do.
...	1	4to.
...	1	4to.
...Memoirs ...	3	8vo.
...	1	[illegible]
...	1	Imp.
London and Birmingham Railroad	1	Imp.
...	2	8vo.
...	3	do.
— do — do — Plates	1	4to.
...	1	8vo
... and Examples of Modern ...	1	4to.
do. do. do. Plates	1	Imp.
...	1	8vo.
...Hydraulic Tables	1	8vo.
...Improvement of River Navigation	1	8vo
...Practice	4	4to.
...Report, ...	1	Folio
...Tables ... in degrees	1	4to
...Hydrodynamics	2	8vo
...	1	4to
...on ... Roads	1	8vo
— do — do — do	1	do.
... 1843-1851	9	4to
...Grammar of Philosophy	1	12mo
...Economy of Manufactures	1	8vo
...Dictionary of Science, Literature and Art	1	8vo
...Encyclopaedia of Arts, Manufactures & Machinery	1	4to
...on Materials	1	8vo
...Model Calculator	1	do.
...man on Tools and Machines	1	8vo
— do — do — Plates	1	Fol.
...on the Steam Engine	1	4to
...Geometrical Illustrations	1	4to
...Manual of Chemistry	2	8vo
...Specifications for ...	1	do.
...1851	1	4to

[illegible]

Brooks Designs for Cottage and Villa Architecture
[illegible] Patent process of preserving Timber &c.
Brandons Parish Churches
Barlow on Materials
[illegible] [illegible] and Railway Bridges
Do. Do. Do. Plates
[illegible] Reports on Canals &c.
[illegible] on [illegible]
[illegible] Encyclopaedia of Civil Engineering
Civil Engineers and Architects Journal 1838–1851
Do. Do. Do. 18[illegible] and 18[illegible]
Civil Engineers Institution [illegible]
[illegible]
[illegible] Journal of Natural History
Civil Engineers and Architects Journal 1852
[illegible] Hydraulique
[illegible]
[illegible]
[illegible] on Suspension Bridges
Do. [illegible] (Designs of [illegible])
[illegible] (Remagnosi)
Do. [illegible] de Navigation
[illegible] Iron and Brick Bridges and Iron Roofing
Do. Do. Do. Plates
[illegible] Collection of [illegible] 1848
[illegible] Hydraulics
Do. Do.
Douglas on Naval Gunnery
Danas System of Mineralogy
Do. Manual of Do.
[illegible] [illegible] Vol. [illegible]
Downings Architecture of Country Houses
Daniells Elements of Meteorology
Delabeche's Geological [illegible]
[illegible] measurement of the Meridional Arc of India
Do. Do. Do. Plates
Elmes Metropolitan Improvements
Ewbanks Hydraulic Machines
Elliots Practical Geometry (Video)
Fau's Artistic Anatomy
Do. Do. Atlas
Fergus Electricity and Animal Physiology
Fiumi Laghi e Canali di Milano
Thomas Trigonometrical Surveying
Fulton on Canal Navigation
Fergusons Mechanics
Do. Lectures on Do.
Gwilt on Arches
Do. Architectural Criticisms
Grahams Elements of Chemistry
Gauthey's Canaux de Navigation
Goodwyns Memoir on Cast Iron Roofing

Names of Books	No. of Vols.	Size
...'s Mathematics for Practical Men	1	8vo
...'s Ornaments of Lavenham Church	1	4to
...aphy of Architecture	2	8vo
...'s Outlines of Comparative Anatomy	1	do
...'s Antiquities	2	do
...'s Botany	1	do
...'s Principles of Typography (Osmon)	1	do
... on Cements	1	do
...on Road Making	1	do
...'s Canal de Jonction de la Meuse au Rhin	1	4to
Do Do Plates	1	Royal
...'s East India Gazetteer	2	8vo
Do. Do.	1	do
...'s Turning and Mechanical Manipulation	3	8vo
... Forms	1	4to
...ardson on Cast Iron	1	8vo
...'s Outlines of Astronomy	1	do
Natural Philosophy	1	Impl do
...'s Navigation	4	do
...'s [illegible]	1	do
...'s Report on Ventilation	1	do
... of Civil Engineers Reports [illegible] 1849, 50	4	do
...'s [illegible] Plates	1	Impl
...'s [illegible]	1	8vo
Report on the [illegible]	1	fcap
...'s [illegible]	2	8vo
Report on [illegible] Parliament	1	4to
...'s [illegible]	1	8vo
...'s [illegible]	4	8vo
Agricultural [illegible] of India	3	do
...'s Gardener Mechanics	1	do
...'s [illegible]	1	Imp
...'s Chemical Technology	3	8vo
...'s (Faraday's) on the Non-Metallic Elements	1	fcp do
...'s Inland Navigation	1	8vo
...'s Letters on [illegible]	1	do
Agricultural Chemistry	1	do
...t on Railways	1	8vo
...'s Botany (Library of Useful Knowledge)	½	do
Traité de Géométrie Descriptive	1	4to
...and its Environs Topographical and Geological 1851	1	8vo
...'s Floods in [illegible]	1	8vo
...'s Encyclopaedia of Gardening	1	do
...'s Railway Economy	1	p 8vo
...'s Elementary Geology	1	8vo
Principles of Do.	1	do
...'s Mechanical Philosophy	1	do
...'s Illustrations of Mechanics	1	do

[illegible] of Books.

Moseley's Mechanics applied to the Arts	1
Do Engineering and Architecture	1
Müller's Principles of Physics and Meteorology	1
Do [illegible]	1
[illegible] Tables	1
[illegible] of Mechanics & Arts	1
Mahan's Civil Engineering	1
Mathematics (Library of Useful Knowledge)	2
Mechanics Magazine	10
Murray's Encyclopaedia of Geography	2
Mushet on Iron and Steel	1
McCulloch's Commercial Dictionary	2
Do Geographical Do	2
[illegible] Limes and Mortars	1
Naval Dry Docks of the United States	1
Navier's Memoire sur les Ponts Suspendus	1
Do Do Do Plates	1
Notes on building and brickmaking	1
Nicholson's Principles of Architecture	3
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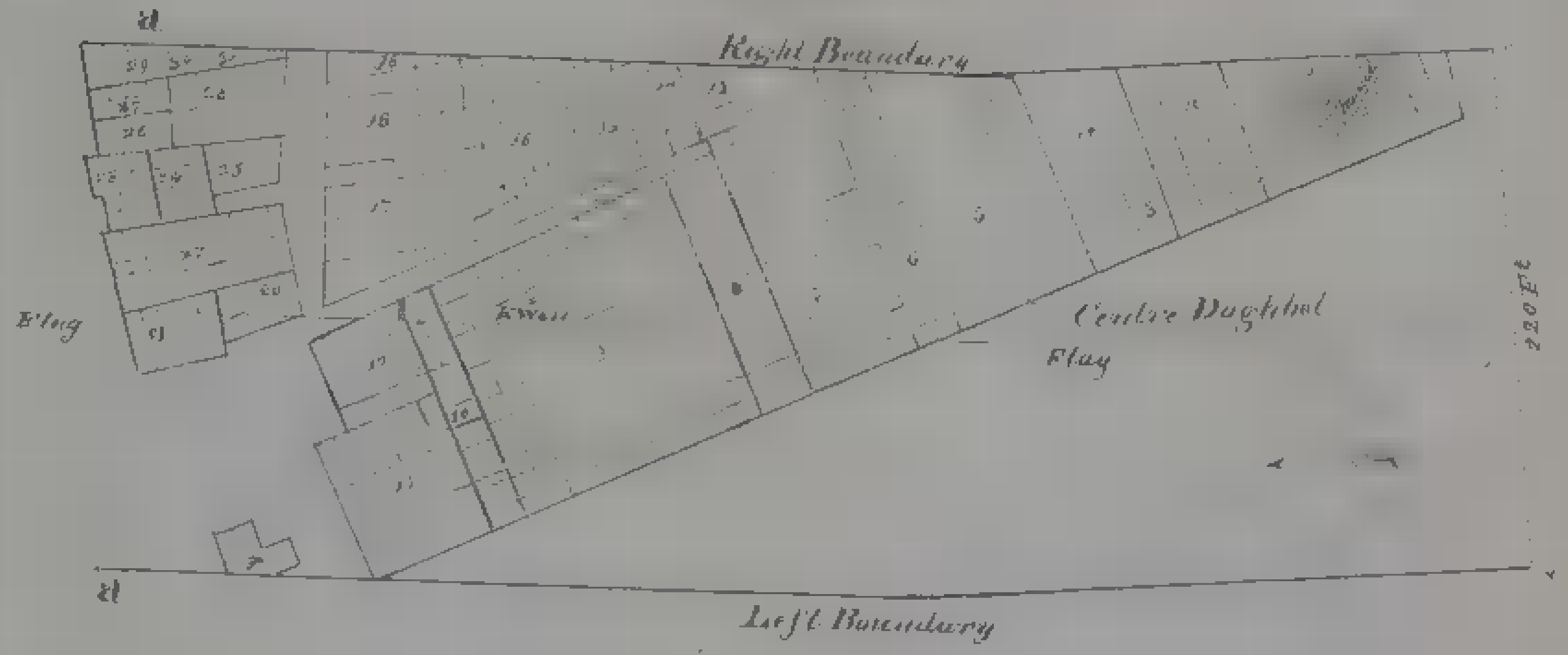

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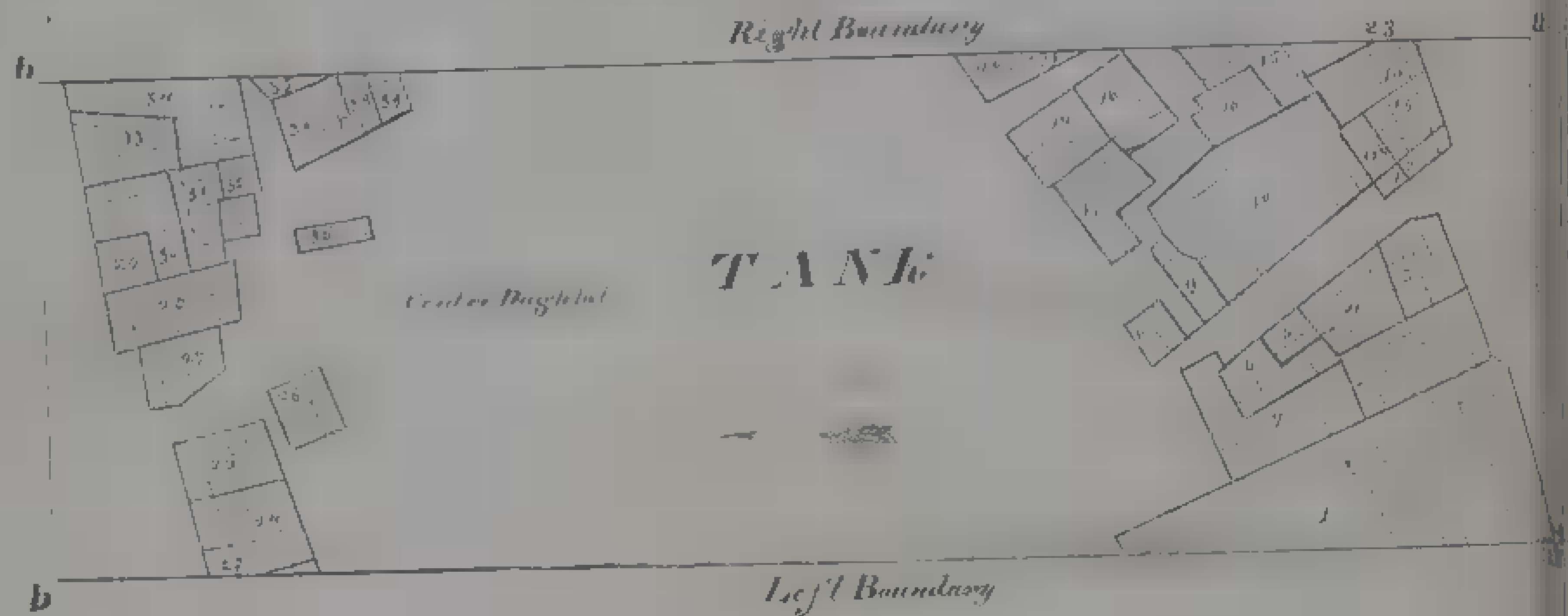

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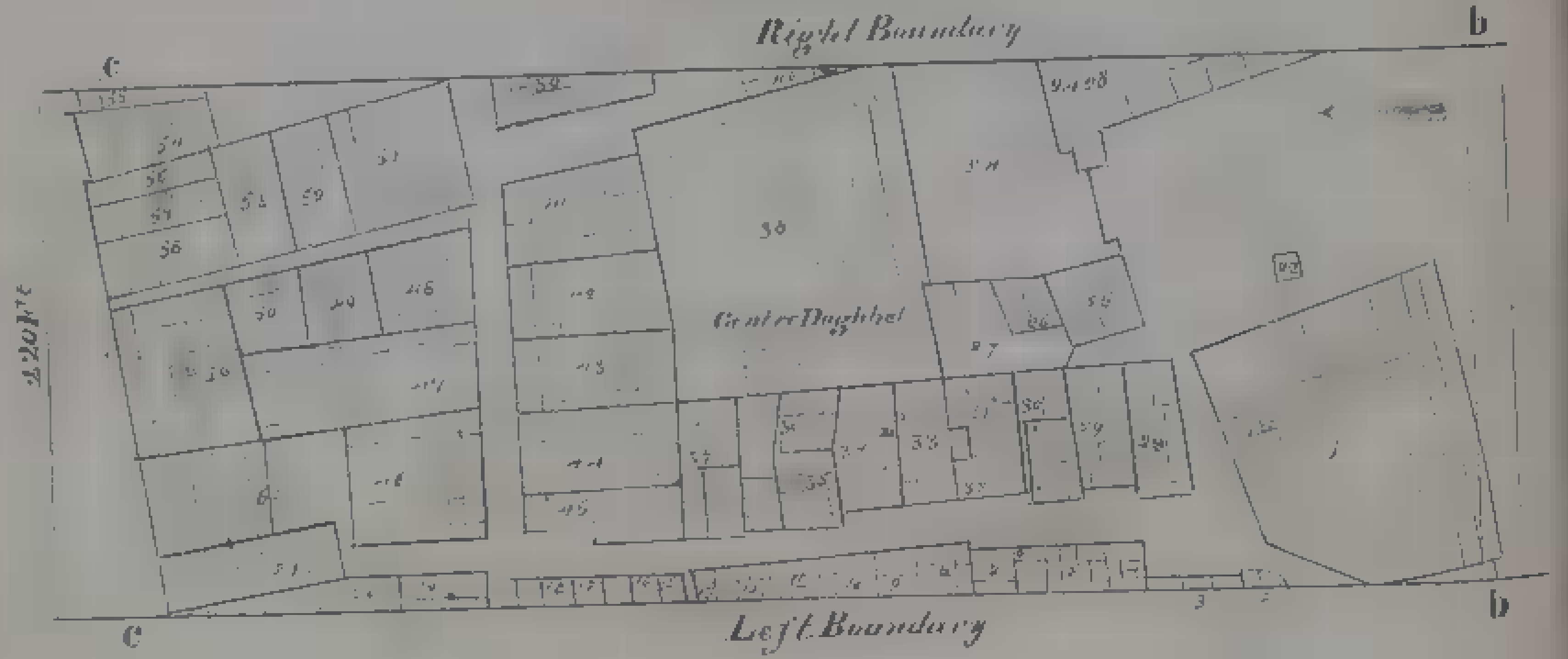

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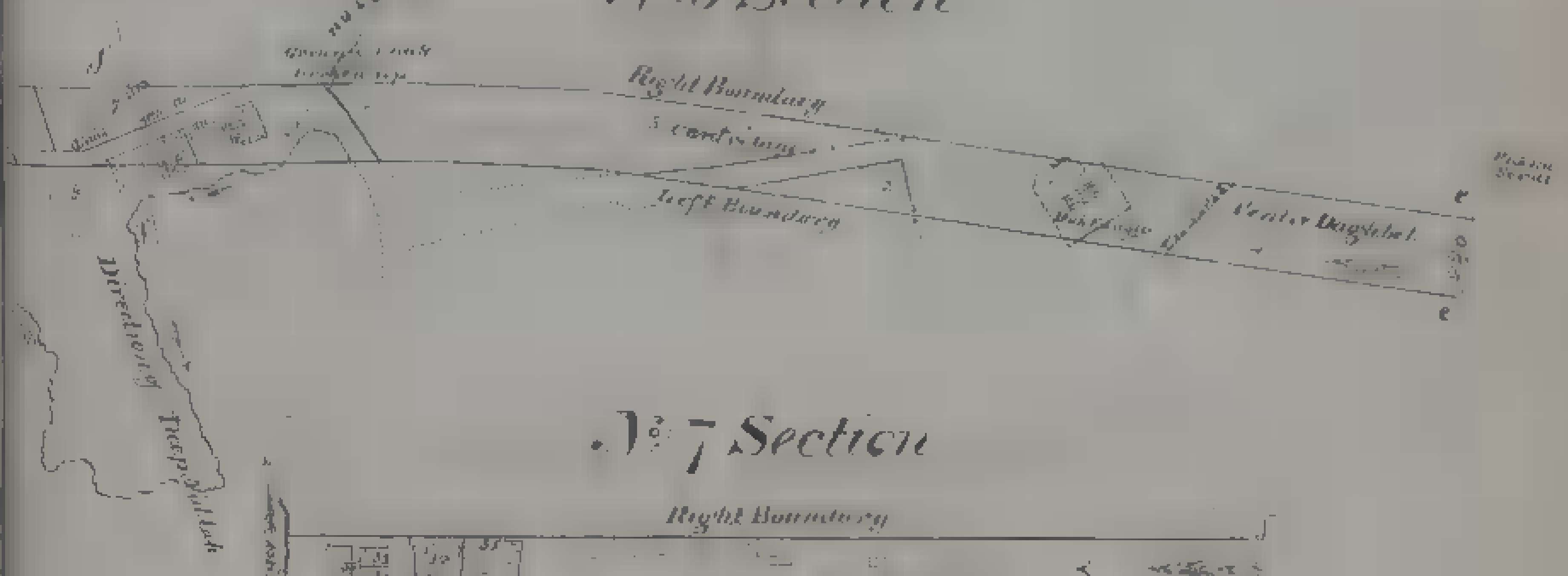

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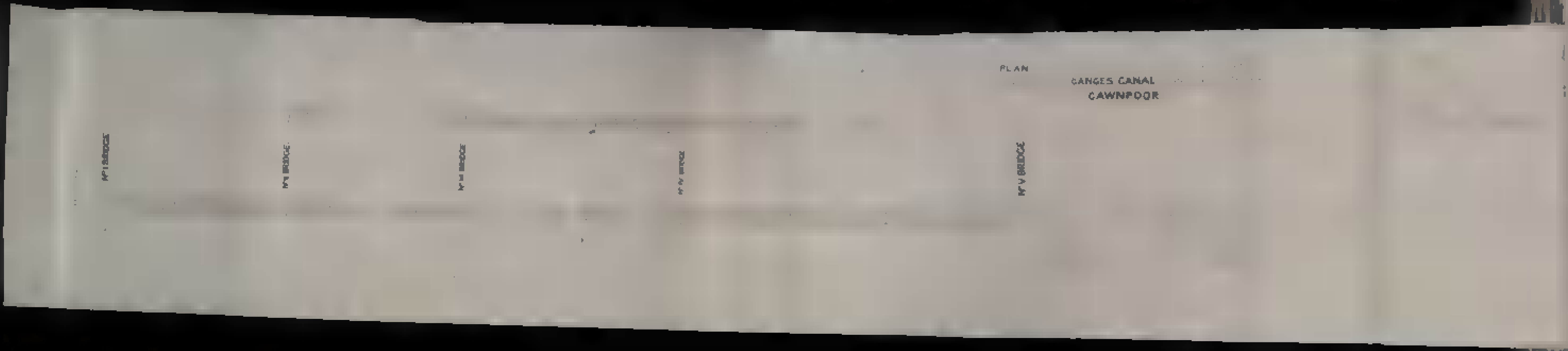
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Lieutenant R. [illegible] } { [illegible] Ali Khan Deputy Magistrate.

No.	Names of and valuation by owners	Description	Remarks by the Committee
1	[illegible] — valuation 3000.0.0	42 Rooms average 10.2 x 8½ – 28 Rooms [illegible] roofs, the [illegible] tile, on walls 11½ high [illegible] 17 Rooms [illegible] halMasonry [illegible] 5 x 4 x 32.	1108 [illegible] feet @ 12/. [illegible] – 132.10.0. 2500 @ 7/. 1750.0 [illegible] 50 x 9 x 5 @ 6/. [illegible] 559.10.0 taken @ 2/. – 91.5.0. [illegible] and [illegible].
2	[illegible] — valuation 150.0.0	[illegible] Rooms average 15 x 8½ 5 [illegible] walls 9½ high [illegible] 1 Shed [illegible]	[illegible] feet @ [illegible] taken @ 1/8/. 11.12.0.
3	[illegible] — valuation [illegible]	[illegible] 15 x 7 [illegible]	[illegible] feet [illegible]
4	[illegible] — valuation [illegible]	[illegible] 15 x [illegible]	[illegible] 10/. [illegible] @ 1/8/. 8/.
5	[illegible] — valuation 90.0.0	[illegible] 12 x 4½ [illegible]	[illegible] 1/12/. taken @ 1/8/. – 1/12/.
6	[illegible] — valuation [illegible]	[illegible] 13 x 7 [illegible]	[illegible] @ 3/8/. [illegible] 18/8/. taken @ [illegible]
7	[illegible] — valuation 300.0.0	[illegible] 16 x 7 [illegible]	10.0 [illegible] feet [illegible] 7/8/. taken @ [illegible] 27/.
8	[illegible] — valuation 67.0.0	[illegible] about 11 [illegible]	340 [illegible] feet @ [illegible] 13/. taken @ [illegible] – 5/.
9	[illegible] — valuation [illegible]	[illegible] 9 x 7 [illegible]	60 [illegible] feet @ [illegible] = 2/3/. taken @ 1/8/. = [illegible]
10	[illegible] — valuation 20.0.0	6 Rooms average 9½ x 7½ [illegible] walls about 8' high in [illegible]	971 [illegible] feet @ [illegible] 23/. taken @ 1/8/. – 11/8/.
11	[illegible] — valuation 125.0.0	4 Rooms average 10½ x 8 [illegible] about 7 high in fair order 4 Rooms with 2 [illegible]	236 [illegible] feet @ [illegible] 15/. taken @ 2/. 4/.
12	[illegible] — valuation 50.0.0	2 Rooms average 11⅓ x 6⅔ [illegible] tiled roofs [illegible] about 13½ high in fair order	150 [illegible] feet @ [illegible] = 10/. taken @ [illegible] = 4/.
13	[illegible] valuation 100.0.0	[illegible] 10 x 5½ [illegible]	227 [illegible] 11/12/. taken @ 2/. 4/8/.

14 [illegible] ——— 6 [illegible] 16½×6½ – 2 [illegible] and 1 [illegible] [illegible] cubic feet @ [illegible] = 1/2 [illegible] @ 1/- = 6/9
valuation — 110.0.0 — [illegible] 3½' high in [illegible] ——— [illegible]

15 Moona ——— 5 Rooms [illegible] 12×6 – 4 [illegible] and 1 [illegible] 360 cubic feet @ [illegible] = 15/- [illegible] @ 1/- = 3/6/-
valuation 300.0.0 [illegible] ———

16 Bushkia ——— 2 Rooms [illegible] 16½×16½ [illegible] walls about [illegible] 216 cubic feet @ [illegible] = 6/8 [illegible] @ 1/- = 3/4/-
valuation — 32.0.0 — [illegible] build. ———

17 [illegible] ——— 5 Rooms 16½×6½ 8 [illegible] walls [illegible] high 315 cubic feet @ [illegible] = 12/- [illegible] @ 1/- = 4/12/-
valuation — 20.0.0 [illegible] ———

18 [illegible] ——— 3 [illegible] 16½×6½ – 4 [illegible] and 3 [illegible] walls 300 cubic feet @ [illegible] = 21/- [illegible] @ 2/- [illegible]
valuation — 5.0.0 — about [illegible] high [illegible] ———

19 [illegible] ——— 1 Room 8½×7½ [illegible] [illegible] feet @ [illegible] = 2/8/- [illegible] @ 2/- = 1/3/-
valuation [illegible] ———

20 [illegible] ——— 1 [illegible] [illegible] 7½' [illegible] [illegible] cubic feet @ [illegible] = 8/15/- [illegible] @ 1/- 3/-
valuation 20.0.0 — [illegible] ———

21 [illegible] ——— 1 Room 15½×6½ ——— do ——— do ——— do ——— [illegible] cubic feet @ [illegible] = [illegible] @ 1/- [illegible]
valuation 16.0.0 — [illegible] taken ———

22 [illegible] ——— 2 Rooms 12½×8 [illegible] [illegible] cubic feet @ [illegible] = 11/- [illegible] @ 1/- = 3/-
valuation 16.0.0 — [illegible] ———

23 [illegible] ——— [illegible] the house [illegible] high [illegible]
valuation 0.0.0 [illegible] ———

24 [illegible] ——— 6 Rooms [illegible] 10½×7½ [illegible] walls [illegible] high [illegible] [illegible] cubic feet @ [illegible] = 32/- [illegible] @ [illegible] 10/12/-
valuation [illegible] ———

25 [illegible] ——— 4 Rooms 10½×7½ [illegible] ——— [illegible] feet @ [illegible] = 2/- [illegible] @ 1/- = 9/12/-
valuation 80.0.0 [illegible] ———

26 [illegible] ——— 3 Rooms 11½×8' [illegible] high [illegible] 355 cubic feet @ [illegible] = 17/10/- [illegible] @ 1/- 5/5/-
valuation 26.0.0 [illegible] ———

		[illegible] kucha [illegible]	[illegible] labor @ 3/- = [illegible]
27	Wangine [illegible] — Valuation 50.0.0	3 Rooms 17½ x 8' tile roofs [illegible] walls 10 feet high in bad order	[illegible] cubic feet @ 4/- per % 16/2/- [illegible] 1/8/- = [illegible] in bad order
28	[illegible] — Valuation 151.0.0	4 Rooms 15 x 6½ [illegible] kucha the rest tile roofs and [illegible] rooms [illegible] walls 9½' high in bad order	673 cubic feet @ 6/- per % = 23/12/- labor @ 2/- = [illegible]
29	[illegible] — Valuation 105.0.0	2 Rooms 22 x 10' tile roofs. [illegible] walls 11½' high in bad order	[illegible] cubic feet @ [illegible] per % [illegible] labor @ 2/- = [illegible]
30	[illegible] — Valuation [illegible]	5 Rooms 15½ x 6½ [illegible] walls 9½' high in bad order [illegible]	[illegible] cubic feet @ 4/- per % = [illegible] labor @ [illegible] = [illegible]
31	[illegible] — Valuation 110.0.0	6 Rooms 12¾ x 6' 2 kucha the rest tiled roofs [illegible] with a kucha [illegible] 11½ x 6'	[illegible] cubic feet @ [illegible] per % = [illegible] labor @ [illegible] = [illegible]
32	[illegible] — Valuation [illegible]	4 Rooms 13½ x 7½' [illegible] the rest tiled roofs [illegible] with [illegible] walls [illegible] high in bad order	[illegible] cubic feet @ [illegible] per % [illegible] labor @ [illegible] = [illegible]
33	[illegible] — Valuation 800.0.0	5 Rooms 11¼ x 6½' [illegible] kucha the rest tiled roofs [illegible] walls 11' high in fair order	601 cubic feet @ [illegible] per % = 30 [illegible] labor @ 1/8/- = 9/6/-
34	[illegible] — Valuation 100.0.0	7 Rooms 11¼ x 6½' [illegible] kucha the rest tile roofs, [illegible] walls 6' high in bad order	633 cubic feet @ 5/- per % = 31/8/- labor @ 1/8/- = 9/6/-
35	[illegible] — Valuation 40.0.0	2 Rooms 15¾ x 8½' tile roofs [illegible] walls 6' high in bad order	[illegible] cubic feet @ 3/- per % = [illegible] labor @ 1/8/- = 3/14/-
36	[illegible] — Valuation 64.0.0	4 Rooms 14½ x 6 [illegible] tile roofs [illegible] walls 9 feet high in fair order [illegible] foundations of kucha [illegible] necessary [illegible]	[illegible] cubic feet @ [illegible] per % = [illegible] labor @ 2/- = 6/10/-

[illegible] 3 [illegible] — [illegible] ——— [illegible]

38 [illegible] ——— 3 [illegible] 13' × 6¾ [illegible] 163 [illegible] = 10/ [illegible] = 3/14

[illegible] 3 [illegible] — [illegible] ———

39 [illegible] ——— 1 [illegible] 13¼ × 6½ [illegible] 172 [illegible] = 1/10/

[illegible] 18/ [illegible] ———

Signed [illegible] Hutchinson [illegible]
[illegible] 6th [illegible] [illegible]

Allowing the [illegible]
[illegible]
[illegible]
[illegible] Lieutenant
1849 [illegible]
[illegible]

[illegible] Captain
[illegible] Captain
[illegible]
[illegible]

[illegible]
[illegible] the [illegible]

[illegible]

[illegible] 150.0.0 [illegible] 11 x 5½ = 9/7/- [illegible]

34 [illegible] — [illegible] 11 x 5½ [illegible] = 13/3/-

[illegible] 325.0.0 [illegible] 10 feet —

35 [illegible] — 4 [illegible] 10½ x [illegible] = 13/6/-

[illegible] 270.0.0 [illegible] 11 feet [illegible] —

36 [illegible] — 4 [illegible] 7 x 6 [illegible] 11 feet [illegible] 30/-/- = 113/6/- labor @ 2/-/- = 13/3/-

[illegible] 111.0.0 [illegible] —

37 [illegible] — 5 [illegible] 9½ x 6 [illegible] 4½ feet [illegible] 20/12/- labor @ 1/8/- = 7/9/-

[illegible] 200.0.0 [illegible] —

38 [illegible] — 15 [illegible] 13½ x [illegible] 111/8/- [illegible] 2/-/- = 35/2/-

[illegible] 350.0.0 [illegible] 6½ —

39 [illegible] — [illegible] 10 x [illegible] 3/-/- [illegible] 9/4/-

[illegible] 150.0.0 — [illegible] —

40 [illegible] — [illegible] x 6½ [illegible] 15 [illegible] 30/-/- [illegible] 2/8/- = 3/12/-

[illegible] 300.0.0 [illegible] —

[illegible] —

41 [illegible] — 9 [illegible] 13½ x 4½ [illegible] 5 [illegible] = 13/4/-

[illegible] 160.0.0 [illegible] —

42 [illegible] — 5 [illegible] 14½ x 6½ [illegible] 40/-/- labor @ 4/-/- = 10/4/-

[illegible] 250.0.0 [illegible] —

43 [illegible] — 11 [illegible] 75/-/- labor @ 2/-/- = 18/-

[illegible] 350.0.0 — [illegible] —

44 Brijnath ———— 11 rooms average 12½ x 5 [illegible] pucka roof [illegible] 1000 [illegible] value 200/-/- —
valuation 1000.0.0 — and the rest of [illegible] [illegible] 250 feet [illegible] about 15 feet
high of kucha pukka masonry as also the [illegible], the rest
walls of [illegible] [illegible], partly [illegible] 24 x [illegible] finished.

45 Kaluka ———— 6 rooms average 11½ x [illegible] [illegible] kucha [illegible] 75 [illegible] feet @ [illegible] 45/-/- [illegible] 1/8/- = 11/8/-
valuation 15[illegible].0.0 — [illegible] high, walls [illegible] feet high [illegible] —

46 Khairuddin ———— 11 rooms average 12 x 6½ [illegible] roof [illegible] 1287 [illegible] feet @ [illegible] 103/-/- [illegible] 2/-/- = 23/12/-
valuation [illegible].0.0 — [illegible] 51 feet [illegible] kucha [illegible]

47 Gorakh[illegible] ———— [illegible] 16 x 7½ [illegible] kucha [illegible] [illegible] feet @ [illegible] 36/-/- [illegible] 2/-/- = 10/12/-
valuation [illegible].0.0 — walls [illegible] 11½ feet [illegible] ————

48 [illegible] ———— 4 rooms average 9½ x 7 [illegible] [illegible] feet @ [illegible] 8/-/- [illegible] 2/-/- = 13/-/-
valuation 600.0.0 — [illegible] kucha [illegible] [illegible]
11 feet high [illegible] ————

49 Buldeo ———— 5 rooms average 15 x 7 [illegible] of which is 2 [illegible] 630 sq. feet @ 7/-/- [illegible] 44/2/- value @ 2/-/- = 12/8/-
valuation 600.0.0 — the rest of kucha, [illegible] 11 feet [illegible] ————

50 [illegible] ———— 7 rooms average 11 x 5½ [illegible] of which is 2 [illegible]
valuation [illegible].0.0 — [illegible] of pukka kucha [illegible]
the [illegible] ————

51 [illegible] ———— 19 rooms average 10½ x 6½ [illegible] pukka [illegible] 1200/-/- value 250/-/- ——
valuation 3000.0.0 — and the rest of kucha [illegible] 260 feet [illegible] 16½ [illegible] pukka kucha
[illegible] ————

52 [illegible] ———— 6 rooms average 12 x 6½ [illegible] pukka and the rest 532 sq. feet @ 60/-/- [illegible] = 31/-/- value = 6/-/- ——
valuation 2000.0.0 — kucha, walls [illegible] pukka kucha [illegible]

[illegible] — 2½ feet long and 6½ [illegible] — [illegible] = 5 p. p.

54 Cualooree — 3 rooms [illegible] 7¼ x 8½ [illegible] — [illegible] 1,00 p.p. [illegible] = 40 p.p.
valuation 1050.0.0. 200 f. [illegible] rooms of [illegible] [illegible] [illegible] about 12 feet, [illegible] 21¼ x 13½. —

55 Wjeddue [illegible] — 2 rooms [illegible] 16 x 7¾ [illegible] — 24 [illegible] = 7 p.p. [illegible] 1/8 p. = 3/6 p.
valuation 20.0.0. [illegible] 6 feet [illegible] —

56 [illegible] — 5 rooms [illegible] 9¾ x 6¾ [illegible] value 30 p.p. [illegible] —
valuation 1100.0.0. [illegible] —

57 [illegible] — 7 rooms [illegible] 11½ x [illegible] value 400 p.p. [illegible] 1 p.p. —
valuation 1100.0.0. [illegible] —

58 [illegible] — 5 rooms [illegible] 11½ x 9¾ [illegible] value 400 p.p. value 40 p.p. —
valuation 500.0.0. [illegible] 12½ [illegible] feet [illegible] —

59 [illegible] — 15 rooms [illegible] 14½ x 8 [illegible] 3000 p.p. [illegible] 1000 p.p.
valuation 10000.0.0. [illegible] 12 feet [illegible] 27½ x 12½ [illegible] 12½ x 6½ —

60 [illegible] — 11 rooms [illegible] 13 x [illegible] 2 rooms [illegible] 2000 p.p. [illegible] 650 p.p. —
valuation 11,000.0.0. [illegible] about 16 feet [illegible] —

61 [illegible] — 5 [illegible] 13 x 6½ [illegible] 2 [illegible] 500 [illegible] = 30 p.p. [illegible] 20 p.p.
valuation 1300.0.0. [illegible] —

[illegible] ——— 3 [illegible] 11½ × 5½ [illegible] the [illegible] 1 [illegible] 1/[illegible] [illegible]

Valued at 50. [illegible] ———

[illegible] ——— 3 [illegible] 11 × 6½ [illegible] about 1½ feet high [illegible]

valued at 300. [illegible] [illegible] order ———

[illegible]

[illegible]

[illegible] [illegible] } [illegible]

[illegible] } [illegible] } Members

[illegible] [illegible] }

[illegible]

Bazar and Cantonment [illegible] — Cawnpoor 1st March 1831

4th Section

President — Major [illegible]

Captain [illegible] / Lieutenant [illegible] } — Members — { Captain [illegible] / [illegible] Deputy Magistrate

No	Names of [illegible] & by Owners	Description	Remarks of the Committee
1	Baneeram & Gungadeen — [illegible]	4 rooms average 18 X [illegible] One of tile and the [illegible] of kucha roof. [illegible] pukka masonry [illegible] feet [illegible]	Owner not present. 311 sq. feet @ 10 [illegible] 31/3/[illegible] labour [illegible] 7/12/[illegible]
2	[illegible] / Valuation 1000.0.0	14 rooms average 10½ x 7 of kucha roof [illegible] of kucha pukka [illegible] the [illegible] about [illegible] feet [illegible] 11 x [illegible]	117 sq. feet [illegible] labour [illegible] 29/[illegible]
3	Mungee Ram [illegible]	4 rooms average 13 x 9 [illegible] of pukka roof [illegible] kucha pukka masonry 11 [illegible] feet [illegible] 13 x [illegible]	55 sq. feet = 400 [illegible] labour 100 [illegible]
4	[illegible] / Valuation 300.0.0	[illegible] Rooms average 17 x 6½ [illegible] kucha roof, walls of [illegible] 10½ feet [illegible]	[illegible] labour [illegible]
5	[illegible] / Valuation 2000.0.0	[illegible] rooms average [illegible] x 6½ [illegible] roof [illegible] pukka walls [illegible] rooms [illegible] pukka masonry [illegible] 11 [illegible] feet [illegible] 20½ x 7½	[illegible] 280 [illegible] labour 50 [illegible]
6	[illegible] Bisram / Valuation 4000.0.0	4 rooms average 17 x 7½ [illegible] roof [illegible] the [illegible] pukka [illegible] kucha pukka masonry 11 feet high [illegible] 20½ x 7½	[illegible] 500 [illegible] labour 130 [illegible]
7	[illegible] / Valuation 400.0.0	15 rooms average 16½ x 6½ [illegible] [illegible] pukka [illegible] kucha roofs, walls about 15 feet [illegible] 10½ feet high of kucha pukka masonry, the [illegible]	[illegible] 520 [illegible] labour 110 [illegible]
8	[illegible] Ram / Valuation 7000.0.0	10 rooms average 16½ x 5½ [illegible] pukka roofs [illegible] walls of kucha pukka masonry one side pukka plaster	[illegible] 2200 [illegible] labour = 766 [illegible]

[illegible] 11 rooms [illegible], 10 feet high [illegible]

9 Peshawar [illegible] — 9 rooms [illegible] 11½ × 6½ — 7 roofs [illegible] walls [illegible] — [illegible] = 118/-/- [illegible] 17/13/-
[illegible] — [illegible] 16½ [illegible]

10 [illegible] — 17 rooms [illegible] 13½ × 5½ [illegible] walls [illegible] — 1230 [illegible] feet @ [illegible] 207/-/- [illegible] = 47/8/-
[illegible] rooms [illegible] the [illegible] feet
high in bad order, one [illegible] 10½ × 7½ [illegible]
in [illegible]

11 [illegible] — 17 rooms [illegible] 9½ × 6½ [illegible] — 1200 [illegible] feet @ 25/-/- [illegible] 300/-/- [illegible] = 60/-/-
[illegible] walls [illegible]
[illegible] 11 feet high [illegible] 5½ × 7½

12 [illegible] — 11 rooms [illegible] 12 × 6½ [illegible] — 291 [illegible] feet @ 7/-/- [illegible] 32/10/- [illegible] = 17/14/-
[illegible] feet [illegible]

13 [illegible] — 2 rooms [illegible] 16½ × 6½ roofs [illegible] 11 — 173 [illegible] feet @ 11/-/- [illegible] 17/13/- [illegible] 2/-/- = 4/5/-
[illegible] high [illegible]

14 [illegible] — 1 room 20¾ × 11 [illegible] feet [illegible] — 207 [illegible] feet @ 5/-/- [illegible] = 11/-/- [illegible] = 3/-/-
[illegible]

15 [illegible] — 6 rooms [illegible] 15 × 7½ [illegible] — 130 [illegible] feet @ 6/-/- [illegible] 10/13/- [illegible] 2/-/- = 14/-/-
[illegible] 11 feet [illegible] fair [illegible]
[illegible] 15½ × 6½

16 [illegible] — [illegible] rooms [illegible] 12 × 5½ [illegible] — 5 [illegible] feet @ 20/-/- [illegible] 166/2/- [illegible] 4/-/- = 22/-/-
[illegible] 19 feet long [illegible] 3 feet [illegible] in
fair order.

17 [illegible] — 5 rooms 19 x 6½ [illegible] pukka roofs, 2 story [illegible] [illegible] — Value - 360/-/- labor - 116/-/- —
Valuation 2000.0.0 [illegible] kucha, wall 35 feet [illegible] 11 feet [illegible] kucha pukka [illegible]

18 [illegible] — 7 rooms [illegible] 10½ x 5½ [illegible] tile roofs 2 [illegible] high [illegible] — 80 [illegible] feet @ 20/-/- [illegible] 101/-/- labour [illegible] 42/10/-
[illegible] Valuation 400.0.0 pukka and [illegible] kucha roofs walls [illegible] 11 feet high in [illegible]

19 [illegible] — 10 rooms [illegible] 15 x [illegible] roofs kucha [illegible] about 10 feet — 1100 [illegible] feet @ 10/-/- [illegible] 110/-/- labor @ 2/6/- = 27/12/-
Valuation 410.0.0 high [illegible]

20 Mud [illegible] — 4 rooms [illegible] 11½ x 5½ [illegible] 2 [illegible] high and — 534 [illegible] feet @ [illegible] 42/10/- labor @ 2/5/- = 13/3/[illegible]
Valuation 211.0.0 [illegible] kucha, walls [illegible]

21 [illegible] — 4 rooms [illegible] 15½ x 6½ roofs kucha [illegible] walls — [illegible] = 400/-/- labor = 100/-/- —
Valuation 500.0.0 and 15 feet high in [illegible] [illegible] room [illegible]
kucha pukka [illegible]

22 [illegible] — 3 rooms [illegible] 15½ x 6½ [illegible] kucha [illegible] mud 12 feet — 304 [illegible] feet @ [illegible] 15/-/- Labor @ 1/3/- [illegible]
Valuation 180.0.0 high in [illegible]

23 [illegible] — 1 Room 22¼ x 5½ roof [illegible] walls [illegible] — 130 [illegible] 5/-/- [illegible] 6/[illegible] labor @ 1/8/- = 1/15/-
Valuation 150.0.0 [illegible]

24 [illegible] — 6 rooms [illegible] 11,3 x 8 - 1 roof [illegible] kucha [illegible] 10 feet — 1076 [illegible] feet @ 15/-/- [illegible] = 161/11/- labor @ 3/-/- = 32/5/-
Valuation 210.0.0 high [illegible] 11½ x 7 —

25 [illegible] — 4 rooms [illegible] 17½ x 8½ One roof kucha [illegible] walls [illegible] — [illegible] feet @ 10/-/- [illegible] [illegible]/10/- labor @ 2/5 = 21/11/-
Valuation 500.0.0 [illegible]

28 [illegible] — do — 135,0.0 — 6 — do — do — 17½×7½ two tin roofs, pen [illegible], — do — 7/10 cub feet @ 3/p, [illegible] 35/p/p taken @ 2/p/p = 13/p/p

29 Gooreeah — 3 rooms — do — 20⅔×5 One tile roofs, 7 pan [illegible], wall 63 feet long and 6 [illegible] cub feet @ 2/p/p, [illegible] 132/p/p taken @ 2/p/p = 11/13/p
valuation 500,0.0 feet ... 6½ ft high [illegible] in [illegible], one [illegible] 20⅔×7

31 [illegible] — 12 rooms average 11×7 tin roofs [illegible] the last of [illegible]. 1000 cub feet @ [illegible] taken @ 2/p/p = 20/p
valuation 140,0.0 in [illegible], one [illegible] 20⅔×7

31 [illegible] — 6 rooms average 15×7½ two roofs [illegible] [illegible] [illegible] 662 cub feet @ 10/p/p, [illegible] = 7/17/p taken @ 2/p/p 10/p/p
valuation 500,0.0, 25×6⅔ — walls and 11 feet high, [illegible]

32 [illegible] — 7 rooms average 17×8 — 4 [illegible] and 3 tin roofs also 1 [illegible] 17½×6½ 905 cub feet @ 10/p/p [illegible] = 142/12/p taken @ 2/p/p = 21/p
valuation 500,0.0 walls [illegible] 11 feet high [illegible]

33 [illegible] valuation 0.0.0 — 2 rooms average 10½×7 4 [illegible] and 4 tin roofs [illegible] — 650 cub feet @ 10/p/p [illegible] = 5/12/p taken @ 2/p/p = 11/11/p

34 [illegible] — 1 Room 17×7½ Roof [illegible] [illegible] 17×6½ — [illegible] — [illegible] = 42/14/p [illegible] @ 2/p/p = 10/11/p

(Sd) W. W. Hutchinson Lieutenant
Ex. Eng. 6th [illegible]

Attending the [illegible]

(Sd) John [illegible]
[illegible]

(Sd) Geo. [illegible] Lieut.
Offg Ex. Eng. [illegible]

(Sd) [illegible] Major [illegible]
(Sd) J. Widdell Captain
(Sd) G. [illegible] Captain } Members
(Sd) H. [illegible] Lieut.
(Sd) [illegible]

[illegible] Brigadier
Commanding the Station

Sudder Bazar and Cantonment ______ Cawnpore 19th March 1851 ______

5th Section

Precedent — Major C. [illegible]

Captain [illegible] } ______ Members ______ { Captain J. Riddell
Lieutenant R. Wroughton } { Syed Nadir Alli Depy Magistrate

No.	Name of [illegible] by owners	Description	Remarks by the Committee
1	Bukhtu ______ Valuation 100.0.0	3 rooms average 12 x 6½ two of tile and one of kucha roof mud walls [illegible] high in [illegible] also a tile shed 32½ x 5½ ______	312 [illegible] feet @ 6/- per % 18/12/- Labor @ [illegible] = 4/9/-
2	Baday and Bhowanee ______ Valuation 400.0.0	7 rooms average 10½ x 7 [illegible] roofs [illegible] the rest kucha, walls 11 feet high in [illegible] a shed tiled roof 18 x 3½ ______	717 [illegible] feet @ 12/- [illegible] % 86/- Labor @ 3/- 21/8/-
3	Jumna [illegible] Mata Dan Valuation 400.0.0	5 rooms average 10½ x 10½ kucha roofs walls [illegible] feet high of kucha pukka in [illegible] ______	Value 130/- Labor 236/- ______
4	[illegible] ______ Valuation [illegible].0.0	8 rooms average 12½ x 6½ [illegible] tiled roofs [illegible] kucha [illegible] [illegible] feet high [illegible] a shed tile roof 20 x 6 ______	843 [illegible] feet @ 10/- [illegible] % = 84/4/- Labor @ 3/- = 25/3/-
5	M[illegible] ______ Valuation 0.0.0	[illegible] ______	[illegible]
6	[illegible] ______ Valuation 400.0.0	8 rooms average 16½ x 6½ [illegible] 4 kucha roofs [illegible] a [illegible] 16½ x 5½ ______	1096 [illegible] feet @ [illegible] % = 87/10/- Labor @ 2/8/- = 27/3/-
7	[illegible] ______ Valuation 900.0.0	7 rooms average [illegible] x 7½ — three of tiled and [illegible] kucha roofs mud walls 10 feet high, a tile shed 29¾ x 5¾ ______	1377 [illegible] feet @ 12/- [illegible] % = 161/- Labor @ 3/- = 41/5/-
8	Ch[illegible]sookh ______ Valuation 700.0.0	10 rooms 13½ x 7½ — [illegible] of tile roofs 3 [illegible] kucha, mud walls 10 feet high in [illegible] a tile shed 28 x 5¾ ______	1032 [illegible] feet @ 16/- [illegible] % = 262/14/- Labor @ 4/- = 105/10/-
9	[illegible] ______ Valuation 150.0.0	4 rooms 12 x 7½ — two of tiles and two of kucha roofs mud walls 9 feet high, in [illegible] a tile shed 12 x 6 ______	[illegible] feet @ 10/- [illegible] % 46/8/- Labor @ 2/- = 9/5/-
10	[illegible] ______ Valuation 200.0.0	4 rooms 11 x 8½ — 2 of tiles and 2 of kucha roofs mud walls 9 feet high in [illegible] a tile shed 13½ x 4 ______	450 [illegible] feet @ 10/- [illegible] 45/- Labor @ 2/- = 9/-/-

Ganges Canal
Appendix to R R. Vol III

	Valuation — 445.0.0	6 of kucha roof, and [illegible] 2 rooms [illegible] 12 feet high in fair order, and [illegible] 17½ × 6.	[illegible]
12	Koordial	7 Rooms [illegible] 11½ × 7 — 3 of tiles and 4 of kucha roofs, mud walls 9' high, in fair order, a [illegible] 22½ × 6.	805 cub. feet, @ 11/p. [illegible] = 20/p. Labour @ 3/p. = 24/p.
	Valuation — 600.0.0		
13	Thawfall	5 Rooms 17½ × 7½ [illegible] kucha [illegible] roofs, mud walls 9 feet high, in fair order, 1 [illegible] 23 × 6.	707 cub. feet @ [illegible] = 55/p. Labour @ 2/p. = 15/p.
	Valuation — 200.0.0		
14	Kurka	11 Rooms 16½ × [illegible] — 4 of tiles 7 of kucha roofs, mud walls about 11 high, in fair order, [illegible] kucha [illegible], a [illegible] 59½ × 6.	1209 cub. feet @ 10/p. [illegible] = 134/10/p. Labour @ 3/p. = 38/10/p.
	Valuation — 350.0.0		
15	[illegible]	1 Room 14¾ × 5½ kucha roof, mud walls 6½ feet high, in [illegible] order.	[illegible] cub. feet @ 15/p. [illegible] = 12/4/p. Labour @ [illegible] = 1/10/p.
	Valuation — 30.0.0		
16	[illegible]	6 Rooms [illegible] 12 × 6 — 2 of tiles and 4 of kucha roofs and 1 [illegible] kucha roof, [illegible] 15 × 15, [illegible] 4 × 6, mud walls 9 feet high, in [illegible] order.	633 cub. feet @ 6/p. [illegible] = 83/2/p. Labour @ 1/p. = 8/p.
	Valuation — 50.0.0		
17	[illegible]	13 Rooms [illegible] 11½ × 6½ — 4 of kucha and 11 of tile roofs, mud walls 8' high, in bad order.	1131 cub. feet @ [illegible] = [illegible] Labour @ 2/p. = 12/p.
	Valuation — 100.0.0		
18	[illegible]	1 Room 12 × 5¾ kucha roof, 1 [illegible] 15 × 11½, mud walls [illegible] (14 × 10 × 1½) kucha [illegible], in [illegible] order.	Valuation 150/p. Labour 50/p.
	Valuation — 225.0.0		
19	[illegible]	[illegible] Rooms [illegible] [illegible] × 6 — 1 of tiles 6 of kucha roofs, mud walls 7' high, in bad order.	[illegible] cub. feet @ 7/p. [illegible] = 28/10/p. Labour @ 2/p. = 8/p.
	Valuation — 40.0.0		
20	[illegible]	3 Rooms [illegible] 11½ × 7½ — 1 of kucha 2 of tile roofs, mud walls 8' high, in bad order.	[illegible] cub. feet @ 15/p. [illegible] = [illegible] Labour @ 3/p. = 14/13/p.
	Valuation — 350.0.0		
21	[illegible]	1 Room 11 × 6½ kucha roof, a [illegible] 16½ × 6½, mud walls 9' high, in bad order.	175 cub. feet @ 15/p. [illegible] = 2/4/p. Labour @ 2/p. = 3/8/p.
	Valuation — 17.0.0		

22 [illegible] 257 N.S. — 1 room 13½ x 12½ [illegible] 16 x 12½ [illegible] — [illegible] (a 15 p.p. [illegible] = 34/3 [illegible] (a [illegible] = [illegible]
[illegible] 100.0.0 [illegible]

23 [illegible] — 3 rooms [illegible] [illegible] — 725 [illegible] (a [illegible] 80/12 [illegible] (a [illegible]
[illegible] 200.0.0 [illegible] 11 [illegible]

24 [illegible] — 2 rooms [illegible] 16½ x 7½ [illegible] — 540 [illegible] (a [illegible] 17 [illegible]
[illegible] 100.0.0 [illegible]

25 [illegible] — 2 [illegible] 10 x 7½ [illegible] — [illegible]
[illegible] 50.0.0 [illegible]

26 [illegible] — 2 rooms 16½ x 8 [illegible] — 211 [illegible] (a [illegible]
[illegible] 65.0.0 [illegible]

27 [illegible] 10.0.0 1 room 12½ x 7½ [illegible] — 17 [illegible] (a [illegible]
28 [illegible] 60.0.0 3 [illegible] 14½ x 7½ — do — do — [illegible] — [illegible] — do — do — [illegible]
29 [illegible] — 1 — do — 10½ x 6½ [illegible] — do — 9 [illegible] — [illegible]
30 [illegible] — 1 — do — 14½ x 7 — do — do — do — [illegible] — [illegible]
[illegible]

31 [illegible] — 4 rooms [illegible] 12½ x 6½ — 3 [illegible] — 650 [illegible] (a [illegible] 13/4 [illegible]
[illegible] 15.0.0 [illegible] 11 [illegible] x 7½ [illegible] 11 [illegible]

32 [illegible] — 4 rooms [illegible] x 6 [illegible] — 460 [illegible] (a 15 p.p. [illegible] 70/3 [illegible] (a 3 [illegible] 14 [illegible]
[illegible] 300.0.0 [illegible] 12½ x 5 [illegible] — [illegible]
[illegible] 11½ x 7 —

33 [illegible] — 4 rooms [illegible] 10½ x [illegible] — 42 [illegible] (a 15 p.p. [illegible] 63 [illegible] (a 3 [illegible] = 12 [illegible]
[illegible] 200.0.0 [illegible]

[illegible] Valuation — 150,0,0 with mud walls 12' high in [illegible] — [illegible]

35	Mukka — ditto — 60,0,0 — 4 rooms average 11×7 kucha roof mud walls 6 feet high in fair order	330 [illegible] 20/[illegible] labour @ [illegible] = 7/[illegible]
36	Kunnum (absent) — 1 room 15½×7½ tiled roof & [illegible] 12×6 mud walls [illegible] high in [illegible]	111 — ditto — ditto = 6/11/– — ditto @ 1/8/– = 1/11/–
37	Bhowaneedeen [illegible] 200,0,0 — 3 rooms average 10×5½ kucha roofs, mud walls [illegible] high in fair order	315 — ditto @ 36/[illegible] = 11/3/[illegible] — ditto @ [illegible] = 17/4/–
38	Lall Mahomed — ditto — 150,0,0 — 2 rooms 12×6½ kucha roofs, mud walls 6' high — ditto	306 — ditto @ 24/[illegible] = [illegible] — ditto @ [illegible] = 15/[illegible]
39	Kurreemun — 1 room 15½×7½ kucha roof & [illegible] 11½×6½ mud walls. Valuation — 100,0,0 — 6' high in fair order	336 — ditto [illegible] — ditto [illegible] = 6/11/–
40	Hoolasee — ditto — 50,0,0 — 2 rooms 15½×10 [illegible] kucha roof, mud walls — ditto — ditto	306 — ditto — ditto — 24/[illegible] — ditto @ [illegible] = [illegible]
41	[illegible] — 12 [illegible] average 12½×7½ [illegible] kucha roofs mud walls 12'. Valuation — 500,0,0 — high in fair order	1177 — ditto @ 20/[illegible] = 24/12/– — ditto @ [illegible] = 34/15/–
42	[illegible] (absent) — 2 rooms 17×7½ [illegible] mud walls 6' high in [illegible]	263 — ditto @ [illegible] = 13/2/– labour @ 1/8/– = 3/13/– Carriage [illegible] only
43	[illegible] — 25,0,0 — 1 room 12½×11½ kucha roof mud walls about 6' high in [illegible]	132 [illegible] @ 10/[illegible] = 13/4/– labour @ 1/8/– = 3/3/–

(Signed) [illegible] Hutchinson [illegible]
[illegible] Engineer [illegible]

Attending the Committee
[illegible]
[illegible] Sergeant [illegible]
[illegible]
[illegible] Engineer [illegible]

(Signed) [illegible] Members

(Signed) [illegible]
[illegible]

[illegible] Bazar and Cantonment ——— Cawnpoor 1st March 1831 ———

— 4th Section —

— President — Major C. [illegible] —

Captain [illegible] } ——— Members ——— { Captain [illegible] Liddell
Lieutenant [illegible] } ——— Members ——— { and [illegible] Deputy Magistrate

No	Names of and Valuation by Owners	Description	Remarks by the Committee
1	Banceram & Gungadeen [illegible]	2 rooms average 15 x 3½ one of tile and the other of kucha roof, [illegible] Pukka masonry about [illegible] feet [illegible]	Owner not present. 311 sup. feet @ 10 [illegible] p % . 31 [illegible] [illegible] 2 [illegible] = 7 [illegible]
2	[illegible] — Valuation 1000.0.0	14 rooms average 10½ x 7 of kucha roof [illegible] 3 of kucha pukka [illegible] about 7½ feet [illegible] 11½ x 7½	1171 sup. feet [illegible] [illegible] 73 [illegible] labour @ 2 [illegible] = 29 [illegible]
3	Mongee Ram [illegible]	4 rooms average 15 x 7½ [illegible] of Pukka roof [illegible] kucha [illegible] pukka [illegible] 11½ feet [illegible] also [illegible] 23 x 7½	55 sup. feet = 400 [illegible] [illegible] 100 [illegible]
4	[illegible]doss — Valuation 800.0.0	7 rooms average 17½ x 6½ kucha roof, walls of [illegible] 10½ feet [illegible]	700 [illegible] 64 [illegible] = 18/7 [illegible]
5	[illegible] — Valuation 1000.0.0	9 rooms average 7½ x 6½ [illegible] tile roof and the rest [illegible] pukka walls [illegible] 2 rooms [illegible] pukka [illegible] masonry [illegible] 10½ feet [illegible] 20½ x 7½	[illegible] 280 [illegible] [illegible] 50 [illegible]
6	[illegible] and [illegible] Bisnun — Valuation 4000.0.0	4 rooms average 17½ x 7½ [illegible] tile roof and [illegible] the [illegible] pukka [illegible] kucha pukka masonry 11½ feet high [illegible] 20½ x 7½	[illegible] 500 [illegible] labour 130 [illegible]
7	[illegible] — Valuation 1400.0.0	15 rooms average 16½ x 6½ [illegible] tile roofs [illegible] pukka [illegible] kucha roofs, wall about 16 feet [illegible] and 10½ feet high of kucha pukka masonry, the [illegible] good [illegible]	[illegible] 520 [illegible] labour 100 [illegible]
8	[illegible] Ram — Valuation 7000.0.0	10 rooms average 16½ x 8½ [illegible] pukka roofs, [illegible] walls of kucha Pukka masonry one side pukka [illegible]	[illegible] 2300 [illegible] labour = 766 [illegible]

Cawnpoor 24th May 1853.

Number	Name of Owners	Owner's Valuation Rs As	Board's Valuation Rs As	Nature and extent of Buildings	Nature of Roof &c.	Rate	Remarks by the Boards
1	Lallmanthhan	800 " "	65 "	320 Sup ft Pukka	Flat mud on Kurries	20 Rs per 100 Sup feet	
2	ditto		25 10	320 sup ft [illegible]	Tiled on Kurries	8 Rs per 100 Sup feet	
3	Gungadeen	200 " "	41 10	520 sup feet Kucha	Flat mud [illegible]	[illegible] per 100 sup feet	
4	Muddun [illegible]	500 " "	40 "	500 sup feet Kucha	[illegible] on Kurries	[illegible] per 100 sup feet	
5	[illegible]	[illegible]	[illegible]	[illegible] sup feet Kucha	[illegible]	[illegible] per 100 sup feet	
6	"			[illegible]			
7	Khumani	" "	30 "	[illegible] sup feet Kucha	[illegible]	5 Rs per 100 sup feet	
8	Mudari	"	22 "	[illegible] sup feet Kucha	do do do	5 Rs per 100 sup feet	
9	[illegible]		40 10	[illegible] sup feet Kucha	do do [illegible] good repair	7 Rs per 100 sup feet	
10	Mahomed [illegible]		46 3	[illegible] sup feet Kucha	[illegible]	7 Rs per 100 sup feet	
11	Summa	" "	12 4	[illegible] sup feet Kucha	[illegible] on Kurries	4 Rs per 100 sup feet	
12	Seevu	" "	25 "	[illegible] sup feet Kucha	[illegible]	10 Rs per 100 sup feet	
13	Sowa	" "	3 "	[illegible] Kucha	3 [illegible]		
14	Kushyal [illegible]	"	40 14	[illegible] sup feet Kucha	[illegible] tile on Kurries	7 Rs per 100 sup feet	
15	Merza	"	31 "	[illegible] sup feet Kucha	flat mud [illegible] inferior description	5 Rs per 100 sup feet	
16	Aulhoo	125 "	68 "	860 sup feet [illegible]	[illegible]	8 Rs per 100 sup feet	
17	Bhawani	150	94 "	1280 sup feet Kucha	[illegible] on Kurries	1000 8 Rs per 100 sup feet; 280 [illegible] per 100 sup feet	
18	Doorjun	"	[illegible] 5	150 sup feet Kucha	thatched [illegible]	3 Rs per 100 sup feet	

20	Doena	" " "	35	" 400 " [illegible]	4.00 [illegible]
21	Klodelus [illegible]	" " "	278	" 500 " [illegible]	[illegible]
22	Baddelu [illegible]	" " "	19	" " 300 " [illegible]	5.00 [illegible]
23	[illegible]	" " "	40	" " 750 " [illegible]	[illegible]
24	[illegible]	" " "	70	" " 1000 " [illegible] — Ditto —	[illegible]
25	[illegible]	" " "	36	" " 1450 " [illegible]	[illegible]
26	Moella	" " "	19	" " 300 " [illegible]	[illegible]
27	[illegible]	" " "	30	" " 250 " [illegible]	12.00 [illegible]
28	[illegible]	" " "	60	" " [illegible]	[illegible]
29	[illegible]	" " "	15 9	" 310 " [illegible]	[illegible]
30	[illegible]	" "	20 10	" 310 " [illegible]	[illegible]
31	[illegible]	" " "	14 7	" 200 " [illegible]	[illegible]
32	[illegible]	" "	17 3	" 250 " [illegible] — Ditto — Ditto	[illegible]
33	[illegible]	"	30	" " 300 " [illegible] — Ditto — Ditto	[illegible]
34	[illegible]	" "	21	" " 300 " [illegible] — Ditto	[illegible]
	[illegible]	11791 "			

	[illegible] ——		1171			
35	[illegible] ——		78	420 [illegible]	[illegible]	[illegible]
36	[illegible] ——		150	1000 [illegible]	[illegible]	[illegible]
37	[illegible]		135	2200 [illegible]	[illegible]	[illegible]
38	[illegible] ——			[illegible]		
39	[illegible] ——		1[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible] ——		250	1116 [illegible]	[illegible]	[illegible]
41	[illegible] ——		300	1200 [illegible]	[illegible]	[illegible]
42	[illegible] ——		17	250 [illegible]	[illegible]	[illegible]
43	[illegible] ——		150	1000 [illegible]	[illegible]	[illegible]
44	[illegible] ——		21	300 [illegible]	[illegible]	[illegible]
45	[illegible] ——	10,000	8000	2000 [illegible]	[illegible]	[illegible]
46	[illegible] ——		105	1000 [illegible]	[illegible]	[illegible]
47	[illegible] ——		35	320 [illegible]	[illegible]	[illegible]
48	[illegible] ——		10/13	330 [illegible]	[illegible]	[illegible]
49	[illegible] ——		10	900 [illegible]	[illegible]	[illegible]
50	[illegible] ——		125	250 [illegible]	[illegible]	[illegible]
51	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

55 [illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	330 [illegible]	20 [illegible]
[illegible]	[illegible]	1070 [illegible]	20 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	200 [illegible]	[illegible]
[illegible]	[illegible]	230 [illegible]	12 [illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	250 [illegible]	[illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]
[illegible]	[illegible]	600 [illegible]	[illegible]
[illegible]	[illegible]	300 [illegible]	[illegible]

[illegible] 6,501 [illegible]

[illegible] ———— 6315 [illegible]

51 Kaneo[illegible]	[illegible]	32	[illegible]	[illegible]	12 [illegible]
51 [illegible]	[illegible]	69	[illegible]	[illegible]	6 [illegible]
52 [illegible]	[illegible]	161	1000 [illegible]	[illegible]	16 [illegible]
53 Merbaie[illegible]		11	[illegible]	[illegible]	10 [illegible]

[illegible] ———— [illegible]

L. Lhitton

[illegible] ———— [illegible]

51 Gongon[illegible]	[illegible]	70	[illegible]	[illegible]	11 [illegible]
52 [illegible]	[illegible]	60	[illegible]	do — do — do	10 [illegible]
53 [illegible]	[illegible]	92	1200 [illegible]	[illegible]	500 / 300 [illegible]
54 [illegible]	[illegible]	1000	2250 [illegible]	[illegible]	

56 [illegible]

57 [illegible]	[illegible]	32	[illegible]	[illegible]	[illegible]
60 [illegible]	[illegible]	70	1000 [illegible]	[illegible]	[illegible]
61 [illegible]	[illegible]	105	[illegible]	[illegible]	[illegible]
62 [illegible]	[illegible]	36	[illegible]	[illegible]	5 [illegible]
[illegible]	[illegible]	60	[illegible]	[illegible]	[illegible]

85 [illegible]	" " "	200 " " [illegible]	[illegible]
86 Ditto	" " "	15 " " [illegible]	[illegible]
87 [illegible]	" " "	600 " " [illegible]	[illegible]
88 [illegible]	" " "	180 " " [illegible]	[illegible]
89 [illegible]	" " "	161 [illegible]	[illegible]
90 [illegible]	1000 " "	33 " " [illegible]	[illegible]
91 [illegible]	5000 " "	600 " " [illegible]	[illegible]
92 [illegible]	" " "	21 " " [illegible]	[illegible]
93 [illegible]	" " "	16 " " [illegible]	[illegible]
94 [illegible]	" " "	50 " " [illegible]	[illegible]
95 [illegible]	" " "	27 " " [illegible]	[illegible]
96 [illegible]	" " "	[illegible]	[illegible]
97 [illegible]	" " "	[illegible]	[illegible]
98 [illegible]	" " "	[illegible]	[illegible]
99 [illegible]	" " "	[illegible]	[illegible]
100 [illegible] not found			
101 [illegible]	" " "	[illegible]	[illegible]
102 [illegible]	" " "	[illegible]	[illegible]
Grand Total		[illegible]	

Brought forward ________ 11,081 g.

103	[illegible]	66	250 [illegible]	[illegible]	12 [illegible]
104	[illegible]	25	250 [illegible]	[illegible]	10 [illegible]
105	[illegible]	120	400 [illegible]	[illegible]	30 [illegible]
106	[illegible]	25 6	650 [illegible]	[illegible]	7 [illegible]
107	[illegible]	52	450 [illegible]	[illegible]	8 [illegible]
108	[illegible]	12 10	150 [illegible]	[illegible]	7 [illegible]
109	[illegible]	66	650 [illegible]	[illegible]	12 [illegible]
110	[illegible]	3 9	350 [illegible]	[illegible]	7 [illegible]
111	[illegible]	55	450 [illegible]	[illegible]	9 [illegible]
112	[illegible]	124	1250 [illegible]	[illegible]	10 [illegible]
113	[illegible]	15	300 [illegible]	[illegible]	6 [illegible]
114	[illegible]	24	400 [illegible]	[illegible]	6 [illegible]
115	[illegible]	95	2300 [illegible]	[illegible]	[illegible]

Total [illegible] ________ 12,645 g. [illegible]

Brought forward ________ 12,645 g.

116 [illegible] 1000 500 [illegible]

117	Jumo Tomb Estate		600 " "	[illegible] roofs [illegible] tiles with [illegible] [illegible], [illegible] [illegible] [illegible]. Rent ditto
118	Do.	Do.	1400 " "	A thatched building 2 [illegible] [illegible] 2 [illegible] rooms with [illegible] [illegible] [illegible] [illegible] [illegible] with tiled [illegible] [illegible] attached [illegible] [illegible] 12 [illegible]. [illegible] [illegible] [illegible] repair.
119	M^c Nicol's Estate	2000 " "	2400 " "	A tiled [illegible] of rooms, well [illegible] [illegible] [illegible], [illegible] of building [illegible] in [illegible] repair [illegible] [illegible] [illegible] [illegible] [illegible] Stabling [illegible] [illegible] in the [illegible]
120	Samuel Woolmer [illegible] Estate	Deposit	2500 " "	A [illegible] roofed building 4 rooms with enclosed verandah, [illegible] [illegible] [illegible] side [illegible] open [illegible] [illegible] this [illegible] [illegible] building [illegible] walls of [illegible] brick with [illegible] Plaster [illegible] [illegible] [illegible] in [illegible] [illegible] [illegible] [illegible] closet, [illegible] [illegible] [illegible] [illegible] repair. [illegible] [illegible] [illegible] [illegible] walls [illegible] brick [illegible] [illegible] [illegible] [illegible] [illegible] ditto [illegible] [illegible] 120 feet [illegible] 12 feet [illegible]

Carried forward —— 20,148 " "

Brought over ———— 29148 9 ..

Opiah Ghat

121 Kureem Bux		56 ..	500 [illegible] feet [illegible]	[illegible] Kutcha	900 [illegible] feet
122 [illegible]	2000	2000 ..	2550 [illegible] feet [illegible]	[illegible]	
123 Bunnparshad [illegible]	3000	500 ..	[illegible]	[illegible]	
124 [illegible]		10 ..	5000 [illegible] feet [illegible]	[illegible]	[illegible] feet
125 [illegible]		24 ..	1000 [illegible] feet [illegible]	[illegible] Kutcha	[illegible] feet
126 [illegible]		80 ..	1000 [illegible] feet [illegible]	[illegible]	[illegible] feet
127 [illegible]	500	150 ..	[illegible] feet [illegible]	[illegible]	[illegible] feet / [illegible] feet

[illegible] ———— 29298 .. [illegible]

Attending the Board

Signed Charles [illegible] Capt.
[illegible] 4th [illegible]

Signed [illegible] [illegible]
[illegible]

President Signed [illegible] Bradford [illegible]

Members
Signed [illegible] Captain
Signed [illegible] Captain
Signed [illegible]
Signed [illegible]

Signed [illegible]

[illegible] buildings [illegible] for the Ganges Canal through the Sudder Bazar and Cantonment — [illegible] 26th March 1861

— [illegible] —

— President — Major C. [illegible] —

Captain C. Boulton
Lieutenant [illegible] — Members — Lieutenant C. [illegible]
[illegible]

No.	Names of and Valuation by Owners.	Description	Remarks by the Committee
1	Ramdass — Valuation 25000.0.0	12 Rooms average 19⅝ x 10½. 3 of Kucha roof and the rest of tile. Walls of mud about 10½ feet high and 3 Sheds 16 x 8½ 2 of Grass and one of tile in bad order. Also a temple containing 2 rooms average 16¾ x 9½, and a [illegible] 15½ x 7½ of Pukka masonry, Pukka plastered on both sides and [illegible] high, total height 25 feet, roof Pukka and in very [illegible], also a Pukka Kucha [illegible] [illegible] 3½ feet.	Temple = 7400.0.0 Labor @ 2400.0.0 2909 □ feet outOffices @ 10/-/- p % = 290/-/- Labor = 70/-/-
2	Sabah [illegible] — Valuation — . . .	24 Rooms average 15½ x 9½. 11 of tile roof and 11 of Grass and 2 with a frame of bamboos with no grass [illegible] on them. Walls of mud with the exception of 22 pillars 2½ x 2¼ which are of Pukka masonry, about 10 feet high, also 6 Sheds average 21 x 10. 3 of tile and 3 of Grass. whole in bad order.	Stables 1200.0.0 outOffices huts [illegible] 342.0.0 Gateway 125.0.0 1667.0.0 Labor 400.0.0
3	Ghulam [illegible] and [illegible] — 140.0.0	1 Room 18½ x 7½ of Kucha roof. Walls of mud about 8 feet high in bad order	135 S.feet @ 8/-/- p % = 10/12/- Labor @ 2/-/- = 2/12/-
4	Ukbur Ally — Valuation 200.0.0	2 Rooms average 12½ x 9½ of tile roof. walls of mud about 6½ feet high in bad order	237 Sq. feet @ 7/-/- p % = 16/9/- Labor @ 2/-/- = 4/12/-
5	[illegible] Ally — Valuation 150.0.0	2 Rooms average 12 x 7½. 1 of tile roof 2 stories high and the other of tile Roof	270 Sq. feet @ 10/-/- p % = 27/-/- Labor @ 2/8/- = 6/12/-
6	Budh [illegible] — Valuation 175.0.0	4 Rooms average 8½ x 7½ one of Kucha roof and 3 of tile, 2 storey high walls of Pukka [illegible] masonry 10 feet high in good order	460 Sq. feet @ 14/-/- p % = 64/6/- Labor @ 3/-/- = 13/12/-
7	Jungloo and Budloo — Valuation 35.0.0	3 Rooms average 12 x 6. one of Kucha Roof 2 of tile. walls of mud about 7 feet high, in bad [illegible] formation. 2 walls 12 feet 12 ft long of Kucha Pukka masonry	216 Sq. feet @ 8/-/- p % = 17/4/- Labor @ 2/-/- = 4/5/-

Valuation — 50.0.0 bad order

9 Bhujjoo — 2 Rooms average 21½ × 6½ of tile roof. Walls of Mud 6 feet 279 sq feet @ [illegible] — 22/3/- Labor @ 2/-/- — 8/7/-
Valuation — 100.0.0 high in bad order

10 Ramoo — 1 Room 16½ × 7½ of Kucha Roof, and a tile shed 10 × 6 walls [illegible] — 201 Sq feet @ [illegible] — 16/-/- Labor @ 2/-/- — 10/-/-
Valuation — 50.0.0 — Ditto

11 Daboo — 1 Room 16 × 7½ of tile roof and a tile shed 6 × 7½ Walls ditto — 137 Sq feet @ 5/-/- — 11/-/- Labor @ 2/-/- — 2/12/-
Valuation — 50.0.0 — Ditto

12 Bhukkoo — 3 Rooms average 12½ × 8 One of Kucha Roof and the rest of 2 [illegible] — 277 Sq feet @ 15/-/- — 26/13/- Labor @ 3/-/- — 5/-/-
Valuation — 220.0.0 Story high foundations of Kucha Pukka masonry and walls of mud in good order

13 Munnoo Ram Chuddakoo — 2 Rooms average 19 × 11 one of Kucha roof and the other of tile, also a tile shed 11½ × 7½ walls of mud about 8 feet high in good order — 321 Sq feet @ 8/-/- — 25/10/- Labor @ 2/8/- — 8/-/-
Valuation — 281.0.0

14 Dian — 2 Rooms average 6½ × 6½ of tile Roof, walls of mud about 6 feet high in fair order — 175 Sq feet @ 12/-/- — 21/-/- Labor @ 2/8/- — 4/6/-
Valuation — [illegible]

15 Mohun — 2 Rooms average 7½ × 5½ [illegible] tile roof 2 Story high, and one of Kucha roof a tile shed 5½ × 5½ walls of Kucha Pukka masonry 11 feet high in [illegible] — 200 Sq feet @ 30/-/- — 60/-/- Labor @ 11/-/- — 22/-/-
Valuation — 300.0.0

16 Buldeo Sahoy — 1 Room 25½ × 24½ of Pukka roof walls Kucha Pukka masonry 14 feet high in good order [illegible] Pukka — Value 2000/-/- Labor — 666/-/-
Valuation — 3,500.0.0

17 Moosainee — 4 Rooms average 13½ × 6½ — 3 of Kucha roof, one of tile and a shed of [illegible] × 11 walls of mud 9 feet high in bad order — 337 Sq feet @ [illegible] — 26/13/- Labor @ 2/-/- — 6/10/-
Valuation — 100.0.0

18 Hangun ——— Valuation 50.0.0	2 Rooms average [illegible] of kucha roof walls of mud 9 feet high in bad order ———	140 [illegible] @ 10 [illegible] 14/6 Labor @ [illegible] = 9/10
19 Bhudu ——— Valuation 3000.0.0	4 Rooms average 21 x 10½ three of kucha roof one of tile 2 storey high, walls of kucha pukka masonry 12½ feet high in good order ———	Valuation 1540.0.0 Labor 500.0.0 ———
20 Munshee Kass ——— Valuation — " "	5 Rooms average 17 x 11½ One of pukka, no, one the rest of tile, 4 rooms of one storey and 2 another. One of pukka kucha masonry the rest of mud 11 feet high, a [illegible] storey of pukka roof walls pukka kucha 11 feet high in bad order, all in fair order ———	Valuation 2100/ Labor = 700/ ———
21 Moonna and Munsooka ——— Valuation 1000.0.0	2 Rooms average 41 x 18½ of kucha roof walls of pukka kucha masonry 14½ feet high in good order ———	Valuation 1463/ Labor 1100/ ———
22 Gungadhur and Buddoo ——— Valuation 1100.0.0	5 Rooms average 15 x [illegible] kucha and one of tile roof in [illegible] walls of pukka kucha masonry, [illegible] (31 x 8) which is [illegible] the shed 31½ x 9½ height of the rest walls about 15 feet ———	Valuation 2660/ Labor 700/ ———
23 Kishun Jolay Waligram ——— Valuation 3,000.0.0	1 Room 35½ x 19½ of pukka roof, walls of pukka kucha masonry 16 feet high, in good order ———	Value = 1960/ Labor 650/ ———
24 Mujlis Roy ——— Valuation 700.0.0	1 Room 35⅔ x 21½ ⅗ of grass ⅖ of pukka roof 2 stories high and ⅖ pukka roof and one storey high, walls of kucha pukka masonry 15 feet high in good order ———	Value = 2553/ Labor 560/ ———
25 Sabochurn ——— Valuation 1000.0.0	6 Rooms average 13 x 9 4 of kucha roof and 2 of tile a wall 43 x 2½ of pukka kucha masonry, the rest of mud in bad order ———	[illegible] 224/ Labor 75/ ———
26 Ootah Ram ——— Valuation 3400.0.0	3 Rooms average 15¾ x 7½ one of tile roof 2 storey high and the rest of kucha roof, walls of pukka kucha, [illegible] 11 feet high, [illegible] 20 x 5 ———	Value 1460/ Labor 400/ ———

27 [illegible] — [illegible] Rooms average [illegible] of pukka roof [illegible] Value [illegible] Labor [illegible]
Valuation — 9000.0.0 of pukka roof 11 feet high, walls of kucha [illegible] masonry 11 feet high, base of stone slabs in [illegible] ——

28 Mufles Roy —— 3 Rooms average 43½ x 10 one of pukka masonry of [illegible] 2 storey high, the 3rd of pukka [illegible] (1 story) walls of kucha pukka masonry 12 feet high, [illegible] slabs —— Value = 3000 [illegible] Labor = 1000 [illegible] ——
Valuation — 4500.0.0

29 Chaintchk Weikhtehudan 3 Rooms average 26½ x 11½, of pukka roof walls of pukka kucha masonry, in [illegible], a grass shed 28½ x 9½ [illegible] 15 feet from the side of the nullah, the height is 16½ feet —— Value 3080 [illegible] Labor 900 [illegible] ——

30 [illegible] — 15 Rooms average 21 x 10½ of pukka roof, [illegible] which is [illegible] walls of kucha pukka masonry about 11 feet high, a grass shed 17½ x 8 all in [illegible] —— Value 1500 [illegible] Labor 1600 [illegible] Owners state that they paid 6000 [illegible] for the ground alone and 9000 [illegible] for the buildings ——
Valuation — 16000.0.0

31 [illegible] 1 [illegible] shed 73½ x 11½ [illegible] 10 feet high [illegible] the [illegible] pukka kucha pillars 5½ feet high in [illegible] —— Value — 250 [illegible] Labor 50 [illegible]
Valuation — 1000.0.0

32 [illegible] —— 5 Rooms average 20 x 12 [illegible] of [illegible] roof, 3 of which are 2 story high and the last is pukka roof — 2 walls of [illegible] and 2 [illegible] the [illegible] pukka kucha masonry height about 13½ feet, a [illegible] shed 60½ x 10 all in [illegible] —— Value 3000 [illegible] Labor 900 [illegible] ——
Valuation — 13000.0.0

33 [illegible] and [illegible] —— 2 Rooms average 40½ x 14½, 1 of pukka roof and the other of [illegible] [illegible] and the walls pukka kucha masonry about 13½ feet high in [illegible] —— Value 1900 [illegible] Labor 400 [illegible] ——
Valuation 3000.0.0

34	Wajidshan [illegible] Valuation – 4000, 0, 0	3 Rooms average 22 x 10 two of kucha roof and the 3rd of tile kucha[illegible] have been [illegible] walls of kucha pukka masonry, but [illegible] [illegible] 1832, the [illegible] [illegible]	Value – [illegible] Labor 225/–
35	Bindadhar [illegible] Valuation – " " "	4 Rooms average 11 x 7½ one of pukka and the rest of kucha roofs, walls of kucha pukka masonry, about 10 feet high in bad order. One [illegible] done 6 x 6 on the outside [illegible] 13½ feet high of pukka kucha masonry, no pukka plaster, also a grass shed 15½ x 5	Value – [illegible] Labor – 225/–
36	Setaram [illegible] Valuation – 2000, 0, 0	3 Rooms average 21 x 7½ of pukka roof and 2 storey high walls of pukka kucha masonry about 13 feet high in [illegible] order.	Value 1500/– Labor 500/–
37	Mooma and Chunder[illegible] Valuation – 4300, 0, 0	7 Rooms average 16½ x 5½ two of tile roofs and [illegible] which is 2 storey high and the rest of kucha roof walls of [illegible] 10 feet high [illegible] of the foundation which are of pukka masonry as also the back wall of the house 22 x 9½ feet of kucha pukka masonry which in [illegible]	[illegible] (@ 50/– [illegible] 1[illegible]/– Labor – 27[illegible]/–
38	Chunder[illegible] Bukhsh [illegible] Valuation – " " "	7 sheds average 24½ x 11½ one of tile and the rest of grass on [illegible] supported on one side on mud walls [illegible] feet high and on the other of bullies [illegible] 2 [illegible] bullies only.	[illegible] (@ 6/– [illegible] – 101/– Labor 9[illegible]/–
39	Sadulpersaud and Ubdool [illegible] Valuation – " " "	2 Rooms average 15 x 5½ one of tile and one of grass roof, walls of mud 6 feet high, and a grass shed 17 x 11½ in bad order, part of wall [illegible] about 12½ x 7 and the foundation of that wall of kucha pukka masonry.	3 [illegible] (@ [illegible] – 22/– 231 cubic feet kucha pukka masonry (@ 4/– [illegible] – 10/– and [illegible] – [illegible] Labor – 13/–
40	[illegible]	[illegible] wall [illegible] 21 feet long about 6 feet high in bad order [illegible]	[illegible] 5/– [illegible]

41 [illegible]	[illegible] the other of [illegible].	[illegible] Rs [illegible]
42. Byjnauth	One tile [illegible] and one room with kucha pukka walls 20 x 10½.	Value 400 Rs. Lalu Bhopa's house close to Byjnauth's, are in this instance the value Rs 500 as [illegible] for that house, but as it is a separate property 400 Rs. have been assigned to be given to Byjnauth accordingly 400 Rs. to Byjnauth.

(Signed) [illegible] Lieut.
[illegible] 6th [illegible]

Attending the Committee

(Signed) [illegible] Lieut.
[illegible] Asst. [illegible]

(Signed) [illegible] Lieut.
Offg. [illegible]

(Signed) [illegible] Major President
(Signed) [illegible] Captain
(Signed) [illegible]
(Signed) [illegible] Lieutenant
(Signed) [illegible] Lieut.
} Members

(Signed) [illegible]
Commanding the Station

APPENDIX
O

GANGES CANAL WORKS,—

NORTHERN DIVISION;

By Capt. A. G. GOODWYN, *Executive Engineer.*

ON BLOCK-SINKING.

The object of this paper, and of the tabular statement which accompanies it, is, the discovery of the law which regulates the expense of block-sinking for foundations, as far as the operations in the bed of the Solani torrent.

2. The statement embraces a period of 2 years and 4 months, or from 1st April 1848 to 31st July 1850, and shows the result of block-sinking operations since my connection with the Northern Division Ganges Canal, as far as relates to the Aqueduct Proper, with the exception of sinking 16 wells for the support of the steps on the flanks of the abutments of that work.

3. To render this statement complete, however, similar detail is required regarding the undersinking of the blocks for the support of the curved revetments connecting the work in the bed of the river with that on the banks; and, as these blocks are of uniform size and shape, and both are such as are likely to be more generally adopted in this country than those of many of the very large blocks supporting the heavy weight of the piers and abutments of the Solani Aqueduct, it is much to be desired that a similar record should, hereafter, include them.

4. Again, this statement should embrace the whole of the block-sinking operations in the bed of the Solani, but in it I have not noticed the labors of my predecessor, Lieutenant H. Yule, of Engineers, on account of the monthly progress reports of block-sinking, prior to my receiving charge, showing merely the depth of sinking remaining to be executed for each block. It is true that materials exist for supplying every information that can be desired on this point, Lieutenant Yule's records being most complete and lucid, but as the depths to which blocks were sunk varied greatly, and moreover the sinking of the same blocks was not continuous, the labor of compiling from these records a list which should show each month the progress on each block, with the mean depth at which that progress took place, involves the formation of an entirely new set of progress reports, and is a work greater than I am at present equal to.

5. One great difficulty in framing this statement has been to arrive at the true mean depths at which sinking was performed. This difficulty has beset me at the outset and has not been overcome. As an exemplification of it, suppose, on the first of a month, a block was down 14 feet, and on the last day of the month 20 feet, and that the cost of sinking during the month was 132 Rs. Now, in this case, the rate per running foot would be 22 Rs., the progress being 6 feet; also the mean depth at which sinking was performed was 17 feet. In making my calculations I have used data similarly obtained. But it must not be supposed that the cost of sinking the block from 14 to 17 feet was the same as that from 17 to 20 feet, or that, consequently, as far as the valuation of work goes, 17 feet is the correct mean.

6. In reality, the expense of sinking varies more nearly as the cubic contents of the crater caused by that operation, added to a certain amount of excavation from beneath the crater, or as the cubic contents of a portion of the block taken solid, of the depth sunk, added to some multiple of the cube of that depth sunk, than in any other proportion I am aware of. But what this multiple of the cube of the depth is, can only be ascertained by considering each particular block.

7. For further exemplification, suppose progress as above stated to have occurred on a detached block 20 feet square, the soil to be moved being equal to the content of a crater whose sides run up from the foot of the block everywhere at an angle of 45°.

The cubic content of such a crater would be—

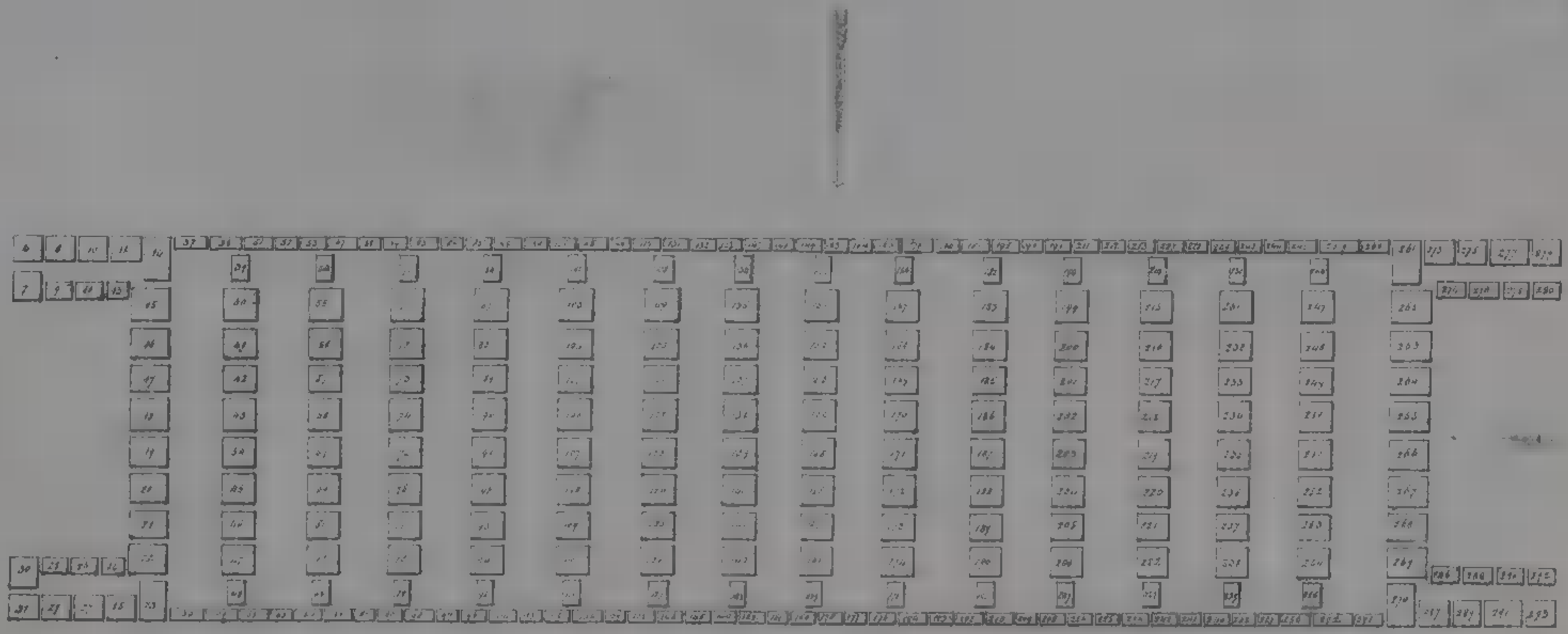
$$\overset{L}{20} \times \overset{B}{20} \times \overset{D}{20} + 4 \times \overset{L\text{ or }B}{20} \times \frac{\overset{D}{20^2}}{2} + \frac{4}{3} \times \overset{D}{20^3} \text{ or}$$

$$20 \times \left\{\begin{matrix}\text{area included in}\\ \text{circumference of}\\ \text{base of block.}\end{matrix}\right\} + 3\tfrac{1}{3} \times 20^3$$

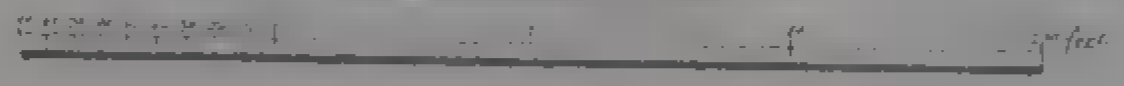
And the work executed on each foot of sinking between 14 and 20 feet would be as follows:

	Modules C. F.		Rs.	A.	P.
15th foot $1 \times 400 + 3\frac{1}{3}(15^3 - 14^3) =$	$2{,}503\frac{1}{3}$	costing	16	9	5
16th do. $1 \times 400 + 3\frac{1}{3}(16^3 - 15^3) =$	$2{,}803\frac{1}{3}$	do.	18	9	3
17th do. $1 \times 400 + 3\frac{1}{3}(17^3 - 16^3) =$	$3{,}123\frac{1}{3}$	do.	20	11	2
18th do. $1 \times 400 + 3\frac{1}{3}(18^3 - 17^3) =$	$3{,}463\frac{1}{3}$	do.	22	15	2
19th do. $1 \times 400 + 3\frac{1}{3}(19^3 - 18^3) =$	$3{,}823\frac{1}{3}$	do.	25	5	4
20th do. $1 \times 400 + 3\frac{1}{3}(20^3 - 19^3) =$	$4{,}203\frac{1}{3}$	do.	27	13	8
By addition $6 \times 400 + 3\frac{1}{3}(20^3 - 14^3) =$	19,920	do.	132	0	0

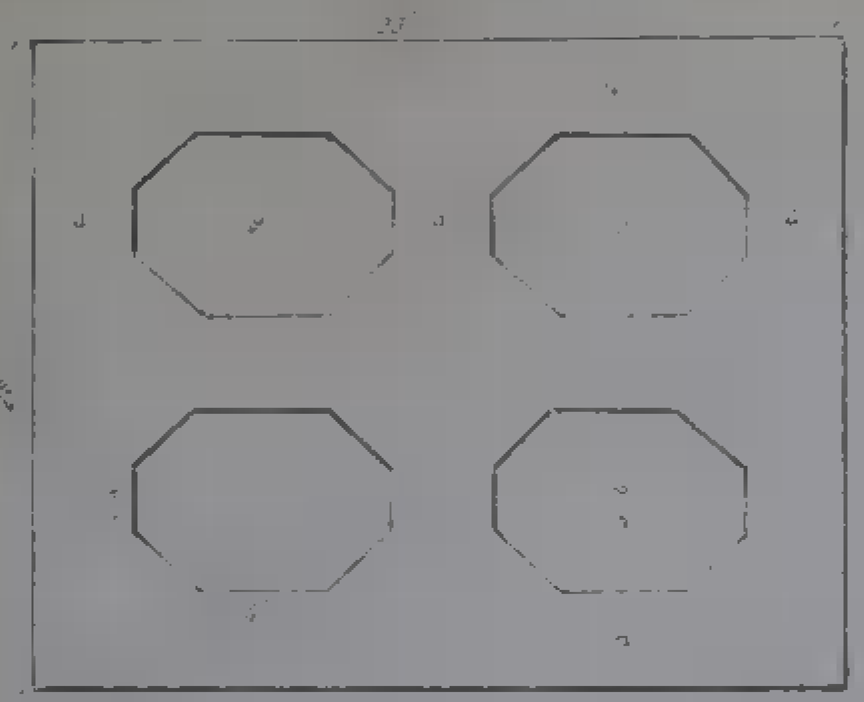
FOUNDATION BLOCKS
of the
SOLANI AQUEDUCT.



Scale 90 Feet to an Inch

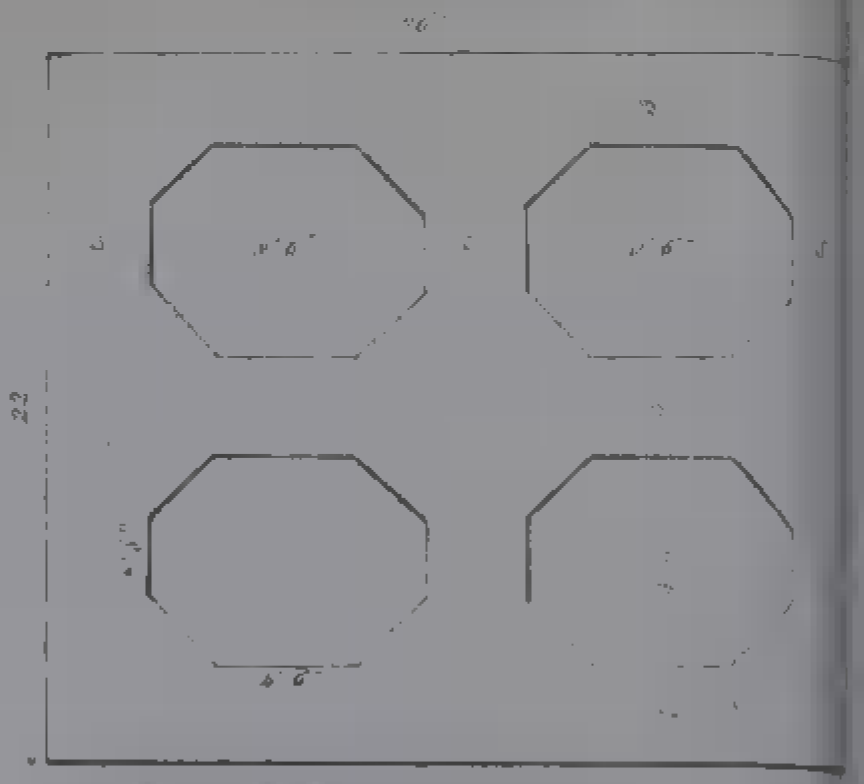


Plan of Blocks Nos 14. 23. 261 270
Supl cont. 353 . 4' Octagon
— do — 324 . 0 Squar



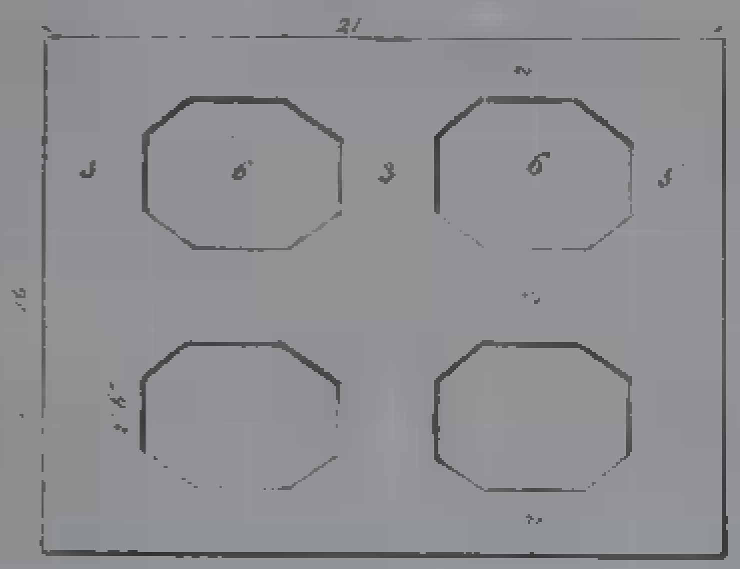
$25 \times 20 - 5 \cdot 5 \times 8 \times 4 = 324$
$25 \times 20 - 5 \cdot 5 \times 8 \times 4 + 1 \cdot 83' \times \frac{3}{4} \times 16 = 353 \cdot 3$

Blocks Nos 15. 16 &c Total 16
Supl cont. 385. 0' Oct.
do — 351. 0' Sq.



$26 \times 22 - 6 \cdot 5 \times 8 \cdot 5 \times 4 = 351$
$26 \times 22 - 6 \cdot 5 \times 8 \cdot 5 \times 4 + 2 \times \frac{3}{4} \times 16 = 385$

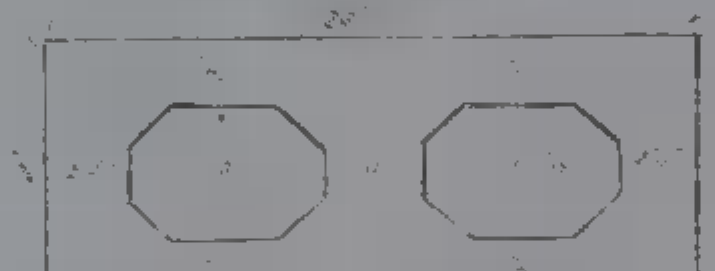
Blocks Nos 8 10 12 &c Total 12
Supl cont. 240' Oct.
do — 225' Sq.



Blocks Nos 9 11 13 &c Total 6
Supl cont. 137.6 Oct
do — 130.0

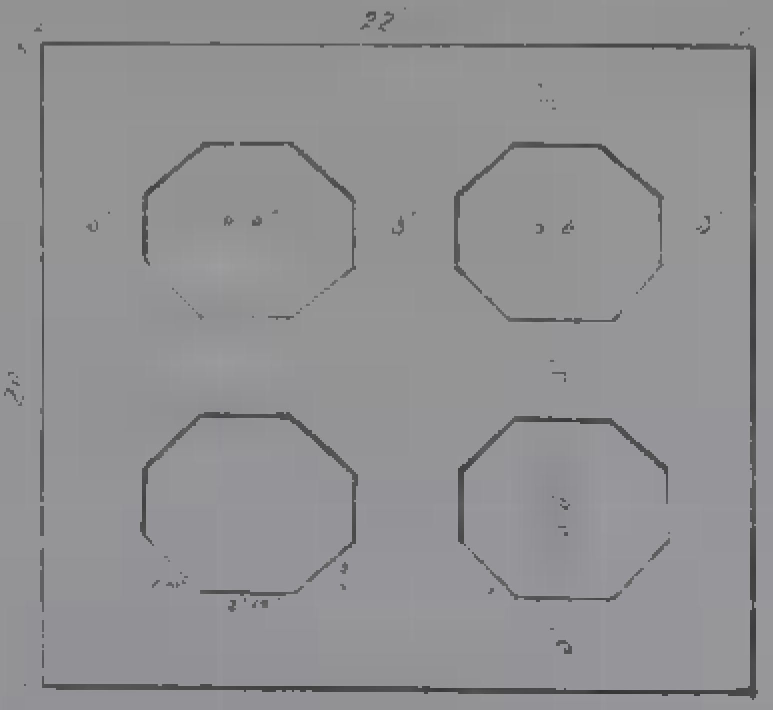
Blocks Nos 276 28
Supl cont. 134

Cutwater Blocks Total 28
Supl cont. 118. Oct.
— do — 112' 0 Sq.



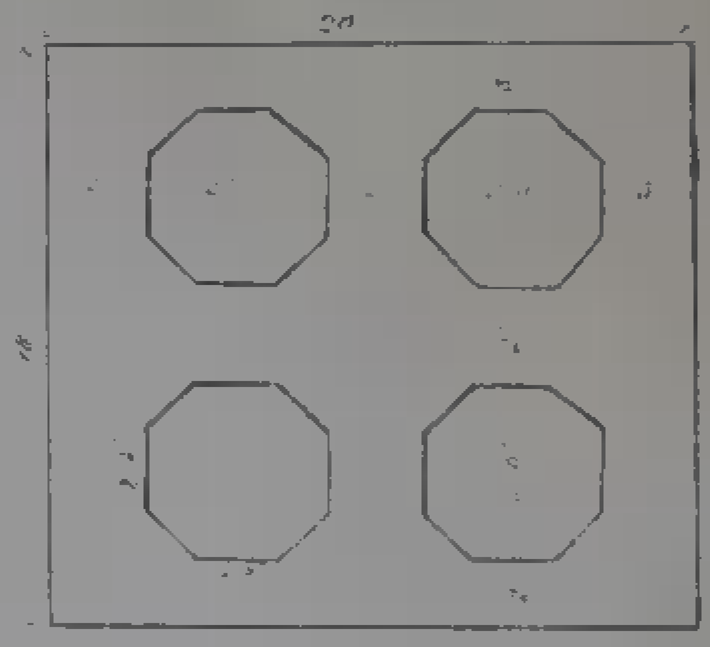
N.B. The curtain
117 and 129 on the
the aqueduct, re
their tops only ha
are of equable thi
ends are vertic
of 1 in

Pier Blocks N.os 40 to 8.ce Total 112.
Sup.l cont. 323. 10½ Oct.
d.o 297. 0 Sq.

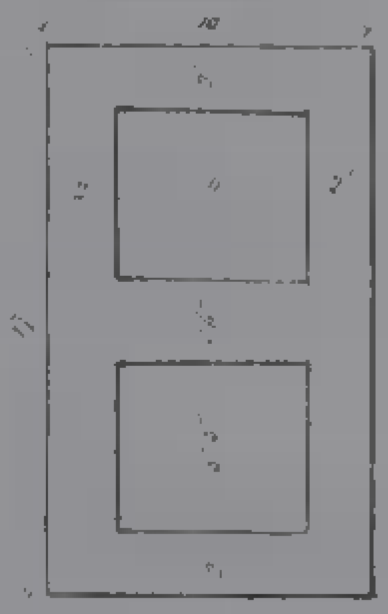


22 x 20 − 6·5 x 5·5 x 4 = 297
22 x 20 − 6·5 x 5·5 x 4 + 1·85 x $\frac{1.85}{2}$ x 16 = 323·9

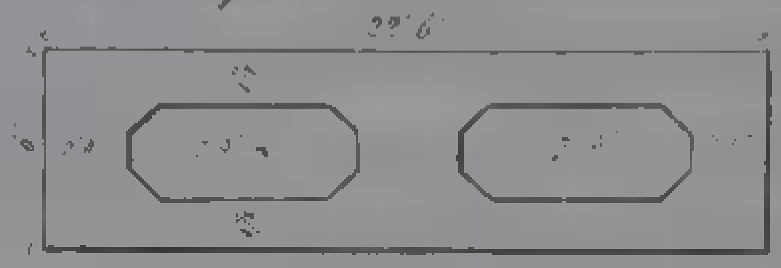
Blocks N.os 6. 7. 30 &c. Total 8
Sup.l cont. 257 Oct.
d.o 250 Sq.



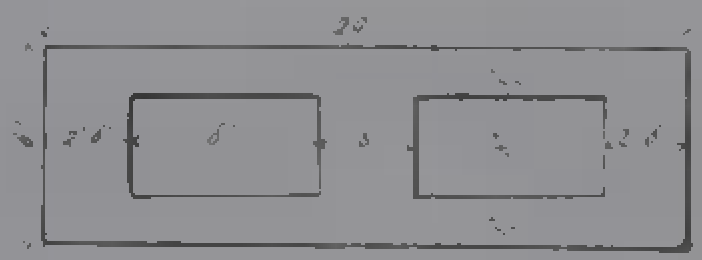
Blocks N.os 274. 278. 286. 290
Total 4
Sup.l cont 107



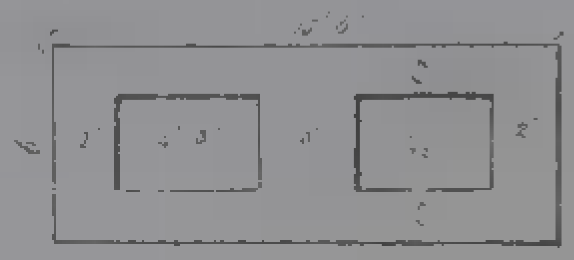
Curtain Blocks N.os 37. 38. 49. 50. 259. 260. 271. 272
Area of Oct. portion 93. 5 Square feet
d.o Sq. d.o 91. 5 d.o



Curtain Blocks N.os 31. 33. 64 &c.
Sup.l cont. 84. 0



Curtain Blocks N.os 52. 65. 68. 81 &c.
Area 67. 5



... and including N.os
... downstream sides of
... the left abutment, have
... in plan. Their walls
... shown, and their
... sides have a batter

Inch

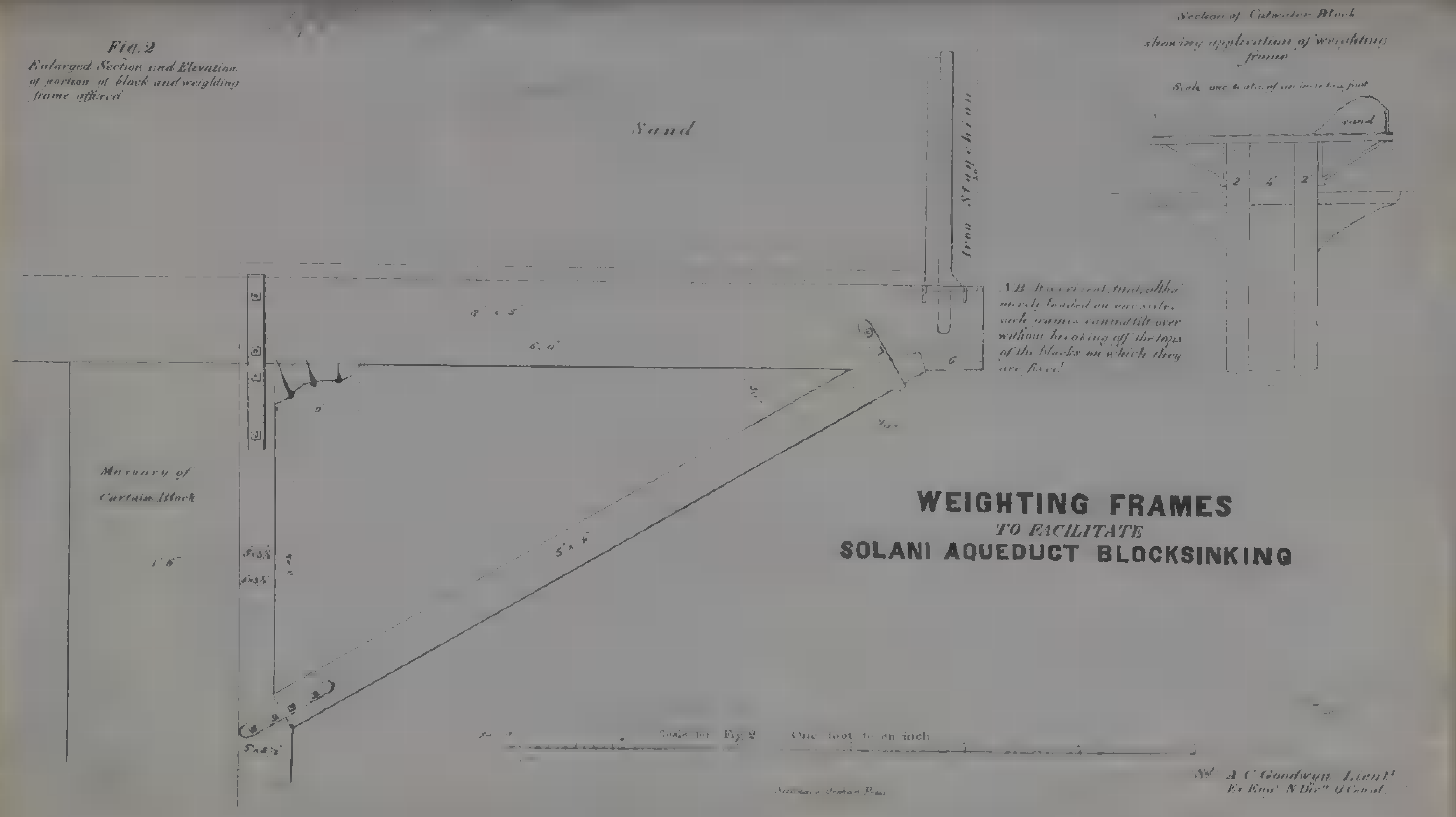


Fig. 2
Enlarged Section and Elevation of portion of block and weighting frame affixed
Sand
Iron Stanchion
Masonry of Curtain Block
N.B. It is evident that, altho' merely loaded on one side, such frames cannot tilt over without breaking off the tops of the blocks on which they are fixed.
Section of Cutwater Block showing application of weighting frame
sand
WEIGHTING FRAMES
TO FACILITATE
SOLANI AQUEDUCT BLOCKSINKING
Scale for Fig. 2 One foot to an inch
Sd. A. C. Goodwyn Lieut.
Ex. Engr. N. Divn. G. Canal

The number of cubic feet of the modulus, or supposed quantity of soil displaced, due to each foot of sinking being known, the cost of each foot is calculated, on that number, by simple proportion; the total number of cubic feet of the modulus being found by the expression; $6 \times 400 + 3\frac{1}{3}\ (20'-14')$ to be 19,920, and the total expense being known to be Company's Rupees 132.

8. Now from this it appears that the mean depth, as far as expense is concerned, is $17\frac{1}{2}$ feet nearly, instead of 17 feet, and that the lower $2\frac{1}{2}$ feet cost as much as the upper $3\frac{1}{2}$ feet, on the whole monthly progress of the block in question.

9. By some such calculation greater accuracy in the statement of mean depths might undoubtedly have been obtained, but the work would have run out to a length that, with the limited time and means at my disposal, I could not pretend to follow.

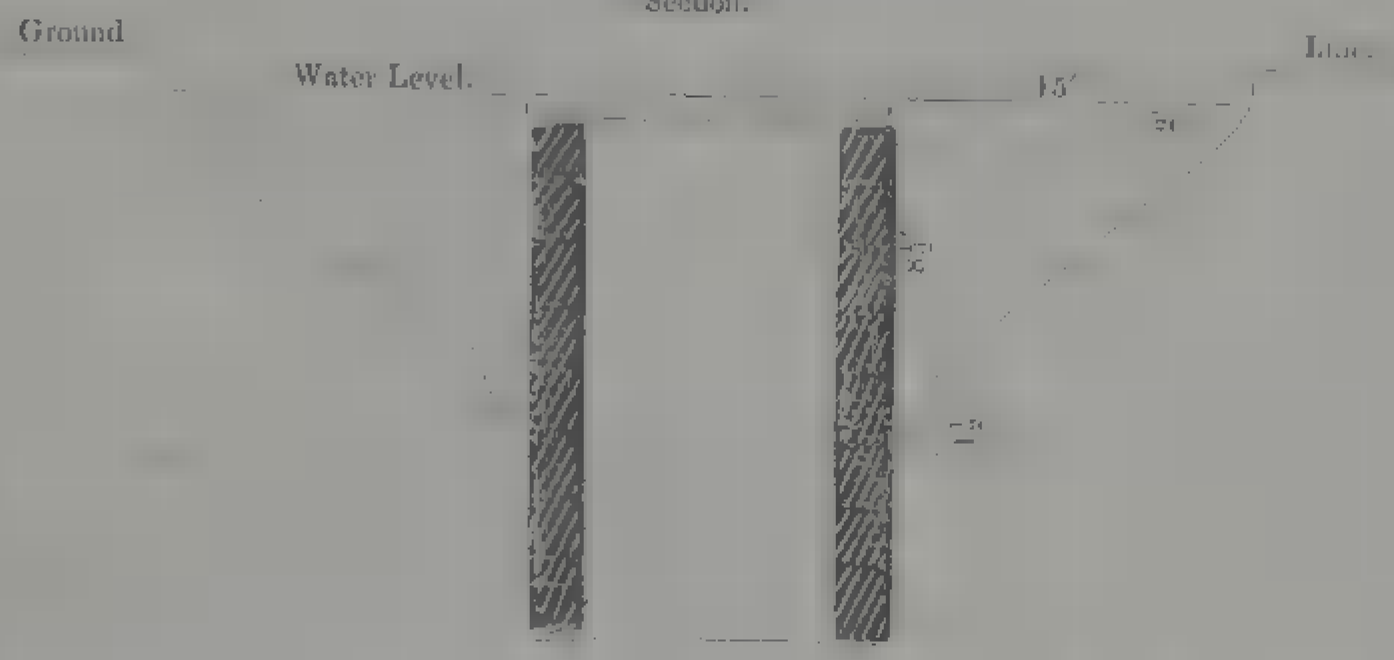
10. The above example is wholly suppositious, and must not be taken as a guide for rates.

11. In the case of heavy blocks, *i. e.* those of 1st, 2nd and 3rd classes, and of the cutwater blocks of the 4th class, the soil has been found at the sides of the craters at a somewhat steeper slope than in that of the long curtain blocks of the 4th class; or rather, I believe, to speak more correctly, in the case of the latter the sand runs down the sides of the craters in a somewhat less steep slope than in the case of the former, owing, as I suppose, to the greater rapidity with which the heavy blocks sink. What I mean to say is, that, in the case of the large blocks, the sand has not time to take the same angle of repose as with the small ones, and consequently the apparent disturbance in the vicinity is less.

12. The section of these craters of course varies with the proportions of clay and sand in the soil, but the following may be taken as average sections:

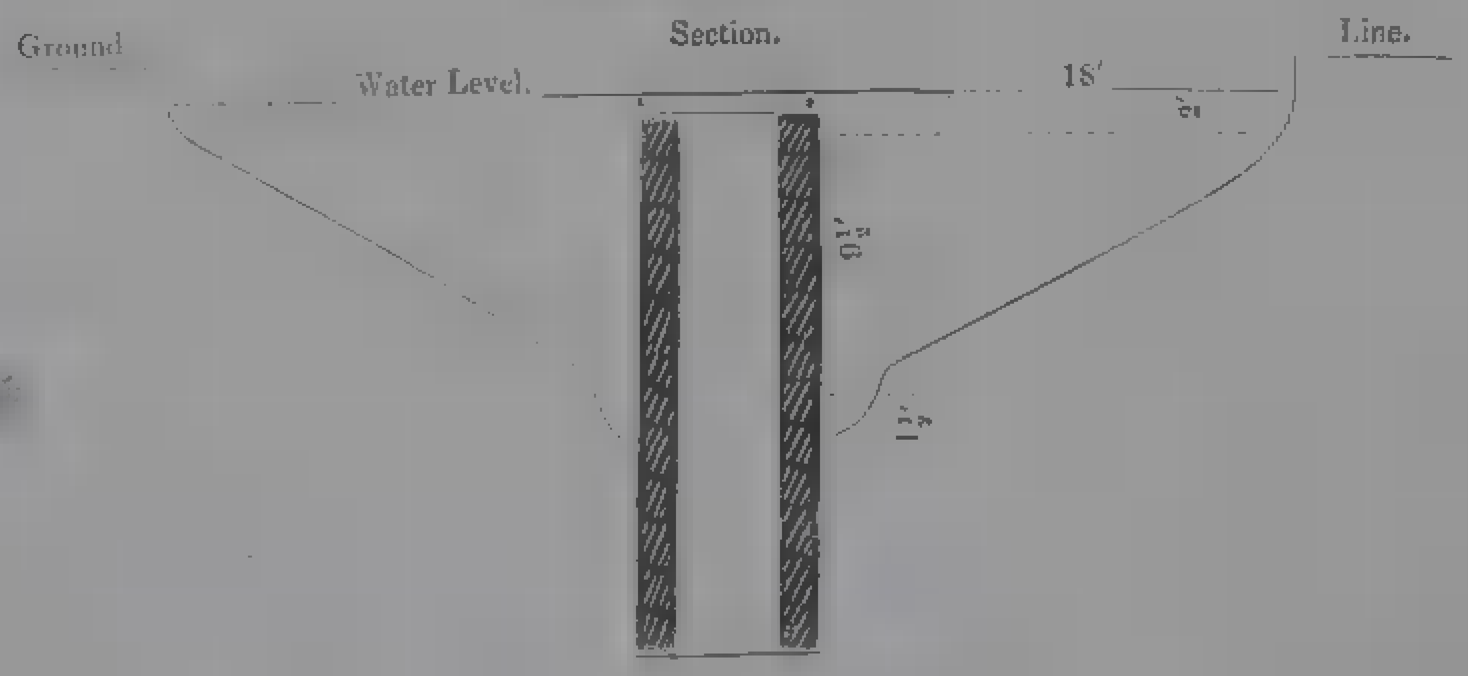
1st, 2nd and 3rd Classes,—and 4th Class Cutwater Blocks.

Section.



Useful Tables for the Canal Department, N. W. P.

4th Class Curtain Blocks.



The sectional areas of these craters possibly vary from 220 to 280 square feet, but neither of these amounts adequately represents the true quantity of soil removed in block-sinking; this true quantity, when the circumferences of blocks are the same, varying inversely in some proportion of the weight to the base of the block, although the discovery of what that proportion is, exactly, is still a desideratum.

13. Any one who has watched the bubbling up of springs, throwing up as they do, when first opened, large quantities of the soil through which they pass, will, I think, agree, that in estimating the craters as running from the feet of the blocks upwards at an angle of 45°, too great an allowance would not be made for the quantity of soil to be removed. My calculations, as far [redacted] they go, prove this; and unless even greater value is assigned to weight of blocks, in proportion to their bases, than I am disposed to allow, the conclusion appears quite sound that in calculating the soil removed, thus, the results [redacted] under rather than over stated. As far as I can discover, no advantage results from the consideration of the above sections as shown in diagram. I give them merely to show that they do not, as might be supposed, afford, from mere inspection, data for estimating the quantity of soil removed. It must be remembered, also, that all that is necessary is to fix a modulus which will afford results *relatively* correct; their being *absolutely* so or not, is not a matter of any practical importance.

14. Having premised thus much, a set of formulæ will follow, by the application of which to the several months' progress and expenditure, the value of the above stated conclusions may be tested. It is, in fact, supposed, that the quantity of soil removed is the same as would be excavated could the blocks be laid in dry in a soil that would stand at an angle of 45.°

The expressions obtained are not the simplest possible algebraically, but are such, as, with the aid of good tables of squares and cubes, will, it is believed, give results with the least possible labor.

Let l be the length in any line of blocks, as a pier, taken up by one block.
b be the breadth of the block.
d ,, depth sunk.
s ,, space or interval between blocks.
n ,, number of blocks.

Thus—

For any number of blocks, of uniform breadth and length in a continuous line, other than the end blocks ..	the formula is,	$n\,\overline{(l+s)\,bd+(l+s)\,d^2}$ or $n\,(l+s)\,(bd+d^2)$
For end blocks of uniform length and breadth, terminating such continuous lines ..	do.	$n\,\overline{(l+\frac{s}{2})bd+(l+\frac{s}{2})\,d^2+\frac{b}{2}d^2+\frac{2}{3}d^3}$ or $n\,\overline{(l+\frac{s}{2})\,(bd+d^2)+\frac{b}{2}d^2+\frac{2}{3}d^3}$
For any single detached block	do.	$lbd+ld^2+bd^2+\frac{4}{3}d^3$ or $lbd+(l+b)\,d^2+\frac{4}{3}d^3$
When the lengths and breadths of blocks in a continuous pier are all uniform, then, for the whole pier including end blocks ..	do.	$(n-2)\,(l+s)(bd+d^2)+2\left\{\overline{(l+\frac{s}{2})\,(bd+d^2)+\frac{b}{2}d^2+\frac{2}{3}d^3}\right\}$ or $d\left\{\overline{n}\,(l+s)-s\,(b+d)+bd+\frac{4}{3}d^2\right\}$

Hence when calculating cost of work at any intermediate stage of progress, if

d represent the greater depth arrived at.
d_1 do. less do. do.

Then—

For any number of blocks of an uniform breadth and length, in a continuous line, other than the end ones ..	the formula is,	$n\,(l+s)\,\overline{bd+d^2} - (bd_1 + bd_1^2)$
For end blocks of uniform length and breadth terminating such line	do.	$n\left\{(l+\frac{s}{2})\,\overline{bd+d^2} - (bd_1 + bd_1^2) + \frac{b}{2}d^2 + \frac{2}{3}d^3 - (\frac{b}{2}d_1^2 + \frac{2}{3}d_1^3)\right\}$
For any single detached block ..	do.	$(d-d_1)\,lb + \overline{(l+b)\,(d+d_1)} + \frac{4}{3}(d^3-d_1^3)$
When the lengths and breadths of blocks in a continuous line are all uniform, then, for the whole pier including the end blocks ..	do.	$n\,\overline{(l+s)} - s \times b\,(d-d_1) + (d^2-d_1^2) + b\,(d^2-d_1^2) + \frac{4}{3}(d^3-d_1^3)$ or $n\,(l+s) - s \times (d-d_1)\,(b+d+d_1) + b\,(d^2-d_1^2) + \frac{4}{3}(d^3-d_1^3)$

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15. It now remains to examine how far this agrees with practice. Certain months have been taken as a test, quite at random, and the rates have been struck on the modulus thus obtained. In the comparison the cost of merely the labor of undersinking has been taken into consideration, as it is obvious that when the total expenditure is not proportionate to the mere cost of labor of undersinking, the causes are foreign to the matter at present under consideration, which is how far this theory is supported by the results obtained from all blocks large or small, and whether it deals satisfactorily with the admitted difference of cost of sinking blocks of varied shape at varying depths.

16. May 1848 is the first month examined. It may be proper to state that the calculations have in all cases been made with the utmost care, (they are not inserted on account of their length,) and that where great differences existed in the mean depths at which sinking was performed, the true quantity of work done has been estimated, as nearly as possible, by dividing the work into small portions, in which the variation in depth was less marked. By the aggregation of the results, obtained from these small portions, totals have been found, on which the rates have been struck. These rates are as follows:

May 1848.					
	1st class	11·93	annas per 100 c. f.	of the modulus.	
	2nd do.	7·90	do.	do.	do.
	3rd do.	11·80	do.	do.	do.
	4th do.	9·78	do.	do.	do.

The variation in rate here noticed is considerable, and it now remains to ascertain what causes exist affecting the rate in some classes more than in others.

Firstly—

1st class blocks.	$\frac{3187}{6733}$	or 0·473 of the whole number of workmen were employed at night.	
2nd do. do.	$\frac{2365}{5683}$	or 0·416 do.	do. do.
3rd do. do.	$\frac{784}{2492}$	or 0·315 do.	do. do.
4th do. do.	$\frac{767}{1985}$	or 0·386 do.	do. do.

This varying proportion of men, employed by night on each class of blocks, *may* be a reason of difference of rate. Lieutenant G. Price, the officer in immediate executive charge of this work, is of opinion that work by night is a saving merely of time, and thinks with me that if possible it should not be resorted to, as being more expensive than work by day only. The difference is not material, however, and I do not assign to this first cause the variation in rate which I seek to explain.*

Secondly—

The effective surplus weight in proportion to the bases of the blocks in their average state of immersion, was—

1st class, 572 lbs. to 1 square foot of area included in circumference of base of block.

2nd do.	507	do.	do.	do.	do.
3rd do.	642	do.	do.	do.	do.
4th do.	552	do.	do.	do.	do.

That the varying proportion of weight to the area of the base has a very material effect on the cost of sinking is beyond dispute, but unfortunately no data exist, by which the ratio of velocity of sinking to weight can be accurately determined.

* These remarks were made merely with reference to defective supervision, and interruptions attendant on work performed at night, but, subsequent to writing them, Lieutenant E. Walker, of the Engineers, drew my attention to the fact of much greater progress being made in sinking a well of his when workmen were employed at considerable intervals than when the work was carried on more rapidly. This was corroborated in the case of a well [illegible] reported. The experiment was then extended to six blocks, in the [illegible] foundations, which were worked at every other day only. The record of the result there, was, however, most unfortunately, vitiated by circumstances which need not be detailed, still every reason exists for believing that [illegible]. Though [illegible] of intermitted block sinking may appear, I strongly recommend [illegible]. Any one who has examined [illegible] kutcha wells and [illegible] in what way the [illegible] only, at the [illegible], will see how intermitted sinking can be recommended [illegible]. Whether however, the benefits that might accrue from sinking [illegible] would not be counterbalanced by the extra expense of either moving the block sinking apparatus, or of making up a double set, is a question [illegible] depend on other circumstances; not the least important of which may be variety of soil to be worked through. A. G. G.

Thirdly—

And this consideration appears the most important of all in the present instance, the height, from whence the jham had to be worked, must be looked to. In the case of the 1st and 3d class blocks, the masonry being 20 feet high, it mattered nothing at what average depth sinking had to be performed, as far as the labor of bringing up any given quantity of earth was concerned. Directly the block was built up from its first height of 12 feet, to its final height of 20 feet, every jham load was raised that height, and the jham-worker had to handle a staff 8 feet longer than before. The time required to work a jham, at the bottom of a block built up to a height of 20 feet, is about one-fourth more than when that block was only 12 feet high. Moreover the jham cannot be forced into the ground so deep as before, and, as the depth of water increases, more and more of the contents of the jham are washed out during its passage upwards; so that the total labor of sinking when the block is 20 feet high, is to the same work when the block is only 12 feet high, as 3 to 2 nearly; or, to speak more correctly, the labor of bringing up any given quantity of soil under these two differing conditions is in this proportion, for it must not be forgotten, that, owing to difference of weight, the *progress*, as before stated, will be greater on any high block, for the same quantity of excavation, than on a low one of the same length and breadth. Now, in the case of the 2nd class blocks, $\frac{264}{672}$ or 0·391 of the work was performed at a height of 12 feet, and, in the 4th class block-sinking, $\frac{61}{[illegible]}$ or 0·14 was done under the same circumstances. If then, correction, fairly due on account of different heights, be applied, giving the workmen credit, as it were, for their work valued at the 12 foot standard, the comparative rates on the modulus would be—

1st	class blocks	7·95	annas per	100 c. f.	
2nd	do.	6·30	do.		do.
3rd	do.	7·90	do.		do.
4th	do.	6·96	do.		do.

It would be easy to show, that, by more accurate calculation of the variation caused by height of blocks, just at the point where the mean depth at which sinking was performed begins to exceed 12 feet, and where the depth of water has not yet materially increased, consequently where the contents of the jham are not materially lessened in their upward passage, these rates would approach each other still more nearly.

17. The next period taken was that of

May 1849.
- 2nd class blocks 7·97 per 100 c. f. on modulus.
- 4th do. do (no curtain blocks) } 8·25 do. do.

2nd class $\frac{5,103}{11,761}$ = 0·434 of the workmen were employed at night.

4th class $\frac{646}{1,370}$ = 0·471 of the workmen were employed at night.

The effective surplus weight in proportion to the bases of the blocks, in their average state of immersion, was—

2nd class 615 lbs. to 1 sq. foot of [redacted] included in circumference of base of block.
4th do. 634 do. do. do. do.

18. These rates agree very nearly with each other; but to render the comparison quite fair, a correction, [redacted] before, has to be applied, altho' owing to [redacted] different cause; after which they may be placed beside those of May 1848.

19. On 1st December 1848 the number of men to each jham was reduced by Lieutenant Price, from 4 to 3, and on 1st November of the [redacted] year the pay of bildars was lowered, by order of the Director of the Works, from [redacted] Rs. to 3-8 per mensem.

The mistry employed superintending the block-sinking asserts that 3 men work a jham *quite* as well as 4; yet this is neither Lieutenant Price's opinion nor my own, although we agree that they perform *nearly* as much work as four. I have very little doubt that the mistry was influenced in his report by a desire to make it as agreeable as possible. Now—

The pay of a squad consisting of 1 tindal at [redacted] Rs. per mensem and of 30 bildars at 4 Rs. per mensem, was, before 1st Novr. [redacted], .. Co's. Rs. 126

Do. do. when the bildars' pay was reduced to 3-8 per mensem, after 1st Novr. 1848, ... „ „ 111

It appears that a saving of $\frac{15}{128} = \frac{5}{43}$ was made, [redacted] labor, by the Director's reduction, and nearly of $\frac{1}{4}$th by Lieutenant Price's reduction; the total saving being $\frac{5}{43} + \frac{1}{4} = \frac{63}{172} = 0·366$.

20. Therefore the same work which was done before 1st Decr. 1848 for 1 Rupee, was done afterwards for $\frac{109}{172}$ of [redacted] rupee.

Consequently the work which in May 1849 cost 7·97 annas, would, in May 1848, have cost 12·57 annas.

21. A reduction [redacted] account of the 12-foot standard to which the work for May 1848 was reduced, or—

$\frac{1}{3} \times \frac{539}{778} \times 12·57 = 2·90$ annas, must be applied to 2nd class blocks, and the proper reduction to the 4th class blocks also, leaving the results for

2nd class blocks 9·67 per 100 c. f. on modulus.
4th class do. 9·74 do. do.

22. If, instead of taking the mistry's statement of saving of one-fourth, by the reduction of windlass men from [redacted] to 3, it were taken at one-fifth, which is

probably nearer the truth, the corrected rate on 2nd class sinking would be 8·77 and that on 4th class sinking nearly the same, affording a very close approximation to the reduced rates of May 1848. As it is, however, the agreement is quite as near as could reasonably be expected, and is nearer than I had anticipated when I commenced the investigation.

23. May 1850 has next been taken.

4th class 10·8 annas per 100 c. f. of modulus.

$\frac{1262}{2772}$ = 0·455 of the whole number of workmen were employed at night.

The weight on the area included in the circumferences of the bases of the blocks is 505 lbs. per sq. foot, in the average state of immersion.

This work would, in May 1848, have cost 17·04 annas per 100 c. f. of modulus, and applying correction of $\frac{1}{3}$ of $\frac{229}{236}$ of 17·04, to effect a reduction to the 12 feet standard of comparison, the rate becomes 11·53 per 100 c. f. of the modulus.

24. For June 1850.

4th class blocks: 11·98 annas per 100 c. f. of modulus.

$\frac{6771}{14340}$ = 0·472 of the whole number of workmen were employed at night.

In the average state of immersion of the blocks, the weight on the area included in the circumferences of their bases was 613 lbs. to the square foot.

Applying corrections necessary, as before described, the rate becomes—

[illegible] = 11·91, less one-third of this amount, (as all the blocks on which sinking was performed this month were at their full height,) or 12·6 annas per 100 c. f. on modulus.

25. For July 1850.

4th class blocks: 13·62 annas per 100 c. f. of modulus.

No work was done at night.

In the average state of immersion of the blocks, the weight on the area included in the circumferences of their bases was 351 lbs. only per square foot. This small proportional weight is due partly to a rise in the water level, this month.

Applying the corrections necessary, the rate becomes—

[illegible] of [illegible] of 13·62 = 14·33 annas per 100 c. f. of modulus.

26. The last three rates are for light curtain blocks with splayed bases. They agree well with each other, and appear to point to an error in the formulæ in calculating the section of soil removed, in the case of a line of blocks, at $bd+d^2$, representing a slope of 45° for the craters. It is very desirable that the expression $bd+\frac{3}{2}d^2$, representing a slope of rather more than 33° should be tried; perhaps, the results, thus obtained, would be found to agree better with each other than those obtained from the formulæ I have made use of.

27. It appears that, on the Solani works,

0·135 of a tindal's day's work, or $\frac{1}{222}$ of his month's work, with 4·054 of a bildar's day's work, or $\frac{5}{37}$ of his month's work, is equal to the execution of 100 c. f. of the modulus, including leave on Sundays; but when the proportion of effective weight to the bases of the blocks may be less than that which obtained in the case of the Solani works, the rate on the modulus must be increased in estimating the cost of labor on future works.

28. What has been stated above refers only to the *labor* of undersinking. It is necessary now, however, to see what the total charge on the modulus, including the cost of removing sand from the tops of blocks, of providing tools, and of defraying sundry trifling contingent expenses, attendant on the work, has been.

May 1848.	1st class	23·22	annas per 100 c. f.	of the modulus.		This variation in rates is owing in great measure to the variable distances to which soil was transported.
	2nd do.	17·80	do.	do.	do.	
	3rd do.	21·39	do.	do.	do.	
	4th do.	20·01	do.	do.	do.	
May 1849.	2nd do.	17·80	do.	do.	do.	
	4th do.	17·59	do.	do.	do.	
May 1850.	4th do.	38·35	do.	do.	do.	
June do.	do. do.	25·85	do.	do.	do.	
July do.	do. do.	30·512	do.	do.	do.	

29. Calculating for a large new work I should say that a rate, on the modulus, of 20 annas per 100 c. f. would cover all expenses, out of which the expense of mere labor of undersinking would not exceed 9 annas per 100 c. f.; the remainder of the charge being for materials, such as rope, oil for torches, &c.; cost of removing sand from blocks; percentage for tools, and sundries. A great saving might be effected on the rate of [illegible] annas per 100 c. f. by the employment of chain, instead of moonge rope. I believe the use of coir rope, even at Roorkee, would have been cheaper than that of moonge.

30. On each block, between every two wells, and on the shore side of that block an earth trough is placed. When operations were first commenced, prior to the earliest date over which this record extends, 10 men were told off daily to the service of this trough, whose duty it was to see that no accumulation of sand took place. This number was soon reduced to 7. On 1st December 1848, when the reduction of men on each windlass from 4 to 3 took place, the number on each trough was reduced to 6, and about 4 months later to 5. The latest distribution for a 4-well block is as follows:

4 windlasses at 3 men each.	12
2 earth troughs at 5 each.	10
Total,	22

Useful Tables for the Canal Department, N. W. P.

This is the smallest number of men that can work a 4-well block with advantage, according to our latest experience.

31. Very much still remains to be done in determining accurately the relative cost of our block-sinking operations in the bed of the Solani; and I look on this paper merely as one step towards that end, involving as it does a satisfactory explication of the laws which regulate the expense of block-sinking. I have found difficulties in valuing the work start up at every step, in the shape of varying circumstances under which, at different periods, sinking was performed, and, until the true value of these disturbing causes is ascertained, absolutely accurate expressions cannot be entered in the formulæ of calculation. Again, until the formulæ are accurately settled, the effects of disturbing causes cannot be properly measured, and thus these two facts cause the question to vibrate like a balance, and each tends, by degrees, to bring the other to a state of rest.

32. From what has been put forth, it appears, that when it is possible to avoid resorting to blocks with splayed bases, they should never be used, at any rate, if the soil through which sinking has to be performed is sandy. The success of such splayed blocks as regards economy, in a clayey soil, is still doubtful, though I think the balance of probability is against their succeeding as well as perpendicular-sided blocks even here. I do not, of course, allude to a case where a broad base is an especial desideratum. I merely say that the minimum width of a block at top being fixed, if that width admits of a perpendicular-sided block being sunk, and if the same width for the base is reckoned sufficient to ensure the stability of the superstructure, a perpendicular-sided block, as susceptible of being sunk far cheaper than a sloping one, is to be preferred; the difference of cost being calculable by the formulæ given above. But a block, 6 feet wide at top with sloping sides, may undoubtedly be sunk where a perpendicular-sided block of the same width at top will not go down at all; generally owing to its falling over on one side, from unskilful working. However, a line of blocks 8½ feet wide, with perpendicular sides, will be built at the same cost, and sunk cheaper than another of the same length, 6 feet wide at top and 11 feet wide at bottom. In the sloping block, the greater loss of weight, during partial immersion, has something to do with this result.

Blocks might always be advantageously designed in such a way that the weighting frames fixed on narrow ones should be applied with equal facility to wide ones. Three such frames as are used on the Solani Aqueduct block-sinking will bear a weight of 25,000 lbs. with safety; nor, with proper precautions, is there any danger in loading half this weight on one side of a block only.

A. G. GOODWYN, *Lieut.*
Ex. Engineer N. Division Ganges Canal.

Roorkee,
26th August 1851.

USEFUL TABLES FOR THE CANAL DEPARTMENT, N. W. P.

Report showing the Progress made, monthly, in sinking each Foundation Block of the Solani Aqueduct Proper, from 1st April 1848 to 31st July 1850.

Roorkee, 26th August, 1851.

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed [illegible] *
1st.	April 1848.	22	5·10	2·550	13·005	
"		23	9·21	4·605	42·412	
"		261	6·75	8·835	59·636	
"		262	3·67	10·375	38·076	
"		263	0·34	12·040	4·094	
"		268	1·00	11·710	11·710	
"		269	2·00	11·210	22·420	
"		270	8·00	8·210	65·680	
			8)36·07		257·033	7·12
			4·51			
"	May 1848.	25	2·13	10·425	25·332	
"		261	7·62	16·020	122·072	
"		262	7·95	16·185	128·670	
"		263	7·66	16·047	122·866	
"		264	7·96	16·10	128·156	
"		265	7·41	15·995	118·523	
"		266	5·79	14·925	86·473	
"		267	7·70	16·06	123·662	
"		268	8·20	16·31	133·742	
"		269	7·20	15·81	113·832	
"		270	9·87	17·145	169·220	
			11)79·79		1,272·548	15·948
			7·25			
"	June 1848.	15	0·54	13·01	7·025	
"		16	0·20	12·84	2·568	
"		17	0·21	13·005	2·731	
"		18	0·38	12·34	4·689	
"		19	5·84	9·94	58·049	
"		20	7·41	9·985	73·988	
"		21	7·30	7·165	52·049	
"		22	6·68	8·44	56·379	
"		261	2·25	20·955	47·149	
"		262	1·92	21·12	40·550	
"		263	2·21	20·975	46·354	
"		264	2·00	21·08	42·160	
"		265	2·38	20·89	49·718	
"		266	4·25	19·955	84·808	
"		267	2·17	20·995	45·559	
"		268	1·67	21·245	35·479	
"		269	2·67	20·695	55·255	
			17)50·17		705·410	14·06
			2·95			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed [illegible]
1st.	July 1848.	14	0·82	13·48	11·053	
"		15	8·58	17·57	150·756	
"		16	7·71	16·795	129·489	
"		17	7·20	16·71	120·312	
"		18	7·53	16·295	122·701	
"		19	6·28	16·00	100·480	
"		20	4·62	16·00	73·920	
"		21	2·62	12·17	31·885	
"		22	2·36	12·96	30·585	
"		23	0·17	11·725	1·993	
			10)47·89		773·168	16·141
			4·79			
"	August 1848.	14	4·62	16·20	74·844	
"		16	1·21	21·305	25·779	
"		17	0·95	20·785	19·745	
"		18	1·08	20·60	22·248	
"		19	1·12	19·70	22·064	
"		20	2·08	19·35	40·248	
"		21	5·24	16·10	84·364	
"		22	6·41	17·345	111·181	
"		23	5·58	14·60	81·468	
			9)28·29		481·941	17·035
			3·14			
"	September 1848.	14	1·08	19·05	20·574	
"		17	0·60	21·56	12·936	
"		18	0·72	21·50	15·480	
"		19	1·60	21·06	33·696	
"		20	1·47	21·125	31·053	
"		21	3·14	20·29	63·710	
"		22	1·31	21·205	27·778	
"		23	4·47	19·625	87·723	
			8)14·39		292·950	20·358
			1·80			
"	October 1848.	14	2·27	20·72	47·054	20·72

* Obtained by dividing the sum of the products, in the 6th column, by the sum of the depths sunk, exhibited in the 4th column.

thus, $\frac{257·033}{36·07} = 7·12$

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on whole class.
2nd	April 1848.	7	0·29	21·715	6·297	
,,		30	11·90	5·95	70·805	
,,		31	11·28	5·61	63·619	
,,		103	6·50	15·03	97·695	
,,		104	4·98	15·56	77·489	
,,		106	4·49	15·275	68·585	
,,		107	6·04	14·92	90·117	
,,		108	4·48	14·64	65·587	
,,		109	3·17	14·775	46·837	
,,		110	4·71	14·255	67·141	
,,		279	12·21	6·155	75·152	
,,		280	12·21	6·155	75·152	
,,		292	12·21	6·155	75·153	
,,		293	12·21	6·155	75·153	
			14)106·68		954·782	8·95
			7·62			
,,	May 1848.	30	1·86	12·83	23·864	
,,		31	2·07	12·315	25·492	
,,		103	1·00	18·45	18·450	
,,		104	2·11	18·775	39·615	
,,		105	0·17	13·995	2·379	
,,		106	1·64	18·01	29·536	
,,		107	1·30	18·26	23·738	
,,		108	0·95	17·025	16·174	
,,		109	1·05	16·555	17·383	
,,		110	0·88	16·72	14·714	
,,		215	14·00	7·00	98·000	
,,		216	12·67	6·335	80·264	
,,		217	13·92	6·96	96·883	
,,		218	12·42	6·21	77·128	
,,		219	12·67	6·335	80·264	
,,		220	12·67	6·335	80·264	
,,		221	12·58	6·29	79·128	
,,		222	12·93	6·165	83·592	
,,		279	7·87	16·145	127·261	
,,		280	7·04	15·73	110·739	
,,		292	7·79	16·105	125·458	
,,		293	8·24	16·33	134·559	
			22)147·83		1,384·885	9·36
			6·72			
,,	June 1848.	103	1·83	19·865	36·353	
,,		104	2·03	20·795	42·214	
,,		105	6·82	17·49	119·282	
,,		106	2·43	20·045	48·709	
,,		107	2·37	20·095	47·625	
,,		108	3·82	19·41	74·136	
,,		109	3·32	18·74	62·217	
,,		110	1·78	18·05	32·129	
,,		215	7·50	17·75	133·125	
,,		216	8·83	17·085	150·860	
,,		217	7·58	17·71	134·242	
,,		218	9·08	16·96	153·997	
2nd	June 1848.	219	8·83	17·085	150·861	
,,		220	8·83	17·085	150·861	
,,		221	8·92	17·04	151·997	
,,		222	8·57	17·215	147·532	
,,		279	2·00	21·08	42·160	
,,		280	2·83	20·665	58·482	
,,		292	2·08	21·04	43·763	
,,		293	1·63	21·265	34·662	
			20)101·08		1,815·217	17·95
			5·05			
,,	July 1848.	30	3·89	15·705	61·092	
,,		31	3·30	15·00	49·500	
,,		87	——	——	——	
,,		88	——	——	——	
,,		89	——	——	——	
,,		90	——	——	——	
,,		91	——	——	——	
,,		92	——	——	——	
,,		93	——	——	——	
,,		94	——	——	——	
,,		103	1·08	21·32	23·026	
,,		105	0·96	21·38	20·525	
,,		106	0·60	21·56	12·936	
,,		107	0·49	21·525	10·547	
,,		108	0·54	21·59	11·659	
,,		109	1·24	21·02	26·065	
,,		110	2·92	20·40	59·568	
			9)15·02		274·918	18·30
			1·67			
,,	August 1848.	30	2·07	17·685	36·608	
,,		31	4·96	19·100	95·590	
			2)6·97		132·198	18·265
			3·48			
,,	September 1848.	30	2·14	20·79	44·491	
,,		31	0·31	21·705	6·728	
,,		87	11·07	5·535	61·272	
,,		88	11·07	5·535	61·272	
,,		89	11·07	5·535	61·272	
,,		90	9·00	4·500	40·500	
,,		91	8·50	4·250	36·125	
,,		92	8·50	4·250	36·125	
,,		93	8·50	4·250	36·125	
,,		94	4·75	2·375	11·281	
			10)74·91		395·191	5·27
			7·49			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on whole block.
2nd	October 1848.	90	2·07	10·035	20·772	
"		91	2·57	9·785	26·947	
"		92	2·57	9·785	26·947	
"		93	2·57	9·785	26·947	
"		94	6·32	7·91	49·991	
			5/16·10		151·601	9·42
			3·22			
"	November 1848.	87	3·53	12·825	45·307	
"		88	2·03	12·085	24·532	
"		89	2·28	12·21	27·839	
"		90	1·45	11·795	17·103	
			4/9·29		114·781	12·36
			2·32			
"	December 1848.	87	4·02	16·61	66·772	
"		88	5·65	15·925	89·976	
"		89	5·02	15·86	79·617	
"		90	5·35	15·195	81·293	
"		91	6·05	14·21	85·975	
"		92	4·88	13·51	65·929	
			6/30·97		469·562	15·14
			5·16			
"	January 1849.	87	1·22	19·23	23·461	
"		88	1·57	19·535	30·670	
"		89	1·95	19·345	37·723	
"		90	1·89	18·815	35·560	
"		91	2·35	18·295	42·993	
"		92	2·52	17·21	43·370	
"		93	5·98	14·06	84·079	
"		94	4·98	13·56	67·529	
			8/22·46		365·385	16·27
			2·81			
"	February 1849.	87	0·48	20·08	9·638	
"		90	0·56	20·04	11·222	
"		91	0·13	19·575	2·240	
"		92	1·25	19·145	23·931	
"		93	2·42	18·26	44·189	
"		94	4·27	18·185	77·650	
"		199	9·18	4·59	42·136	
"		200	9·93	4·965	49·302	
"		201	9·18	4·59	42·136	
"		202	9·85	4·925	48·511	
"		203	10·60	5·3	56·180	
"		204	10·60	5·3	56·180	
"		205	10·76	5·38	57·889	
"		206	9·76	4·88	47·629	
			14/88·97		568·833	6·39
			6·35			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on whole block.
2nd	March 1849.	91	0·62	19·91	12·344	
"		92	0·50	19·97	9·985	
"		93	0·33	19·635	6·480	
"		183	11·43	5·715	65·322	
"		184	12·59	6·295	79·254	
"		185	11·18	5·59	62·496	
"		186	12·59	6·295	79·254	
"		187	12·59	6·295	79·254	
"		188	12·59	6·295	79·254	
"		189	12·57	6·285	79·002	
"		190	12·57	6·285	79·002	
"		199	2·92	10·64	31·069	
"		200	2·34	11·7	27·378	
"		201	3·17	10·765	34·125	
"		202	2·46	11·08	27·257	
"		203	1·75	11·475	20·081	
"		204	1·79	11·495	20·576	
"		205	1·63	11·575	18·867	
"		206	2·56	11·04	28·262	
			19/118·18		838·292	7·09
			6·22			
"	April 1849.	126	1·65	16·975	28·009	
"		185	1·36	12·11	16·470	
"		135	1·61	12·035	19·376	
"		199	7·37	15·785	116·335	
"		200	5·96	15·215	90·708	
"		201	5·77	15·08	87·006	
"		202	6·75	15·635	105·536	
"		203	8·04	16·37	131·615	
"		204	6·50	15·64	101,660	
"		205	7·04	15·91	112·006	
"		206	6·21	15·455	95·975	
"		231	14·03	7·015	98·420	
"		232	14·03	7·015	98·420	
"		233	14·03	7·015	98·420	
"		234	14·03	7·015	98·420	
"		235	14·03	7·015	98·420	
"		236	14·03	7·015	98·420	
"		237	14·03	7·015	98·420	
"		238	14·03	7·015	98·420	
"			19/170·49		1,093·294	[illegible]
			8·97			
"	May 1849.	126	1·73	19·665	34·020	
"		183	8·47	17·035	144·286	
"		184	8·67	16·925	146·740	
"		185	8·47	17·035	144·286	
"		186	8·67	16·925	146·740	
"		187	8·67	16·925	146·740	
"		188	7·57	16·375	123·959	
"		189	8·26	16·7	137·942	
"		190	7·24	16·19	117·216	
"		199	1·67	20.305	33·909	

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
2nd	May 1849.	200	2·92	20·68	60·386	
,,		201	3·02	19·63	59·283	
,,		202	2·08	20·1	41·808	
,,		203	0·75	20·765	15·574	
,,		204	2·25	20·015	45·034	
,,		205	1·71	20·285	34·687	
,,		206	2·58	19·85	51·213	
,,		231	7·37	17·715	130·560	
,,		232	7·37	17·715	130·560	
,,		233	7·19	17·625	126·724	
,,		234	7·37	17·715	130·560	
,,		235	7·37	17·715	130·560	
,,		236	7·37	17·715	130·560	
,,		237	7·37	17·715	130·560	
,,		238	7·37	17·715	130·560	
,,		247	13·94	6·97	97·162	
,,		248	14·11	7·055	99·546	
,,		249	14·18	7·09	100·536	
,,		250	14·39	7·195	103·536	
,,		251	14·32	7·16	102·531	
,,		252	14·24	7·12	101·389	
,,		253	14·20	7·1	100·820	
,,		254	13·69	6·845	93·708	
			33)256·58		3,322·695	13·00
			7·78			
,,	June 1849.	126	0·47	20·765	9·760	
,,		188	1·10	20·710	22·781	
,,		189	0·43	21·045	9·049	
,,		190	1·45	20·535	29·776	
,,		233	0·18	21·310	3·836	
,,		247	7·33	17·605	129·045	
,,		248	7·16	17·690	126·660	
,,		249	7·09	17·725	125·670	
,,		250	6·88	17·830	122·670	
,,		251	6·95	17·795	123·675	
,,		252	7·03	17·755	124·818	
,,		253	7·07	17·735	125·400	
,,		254	7·58	17·48	132·498	
			13)60·72		1085·638	17·88
			4·67			
3rd	April 1848.	25	11·40	5·70	64·980	
,,		27	11·58	5·79	67·048	
,,		29	10·53	5·265	55·440	
,,		273	9·00	7·71	69·390	
,,		275	8·75	7·835	68·556	
,,		277	12·21	6·155	75·152	
,,		287	9·92	7·25	71·920	
,,		289	9·50	7·46	70·870	
,,		291	12·21	6·155	75·152	
			9)95·10		618·508	6·50
			10·57			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
3rd	May 1848.	25	1·67	12·235	20·442	
,,		27	1·75	11·455	20·046	
,,		29	2·89	11·975	34·607	
,,		273	7·70	16·04	123·508	
,,		275	6·62	15·52	102·742	
,,		277	2·62	13·52	35·422	
,,		287	6·95	15·685	109·011	
,,		289	9·87	17·145	169·221	
,,		291	4·95	14·695	72·740	
			9)45·02		687·739	15·28
			5·00			
,,	June 1848.	12	0·12	12·88	1·545	
,,		273	2·17	20·995	45·559	
,,		275	3·25	20·455	66·479	
,,		277	7·25	18·455	133·799	
,,		287	2·92	20·62	60·210	
,,		291	4·92	19·62	96·530	
			6)20·63		404·122	19·58
			3·44			
,,	July 1848.	12	8·92	17·40	155·208	
,,		25	1·74	13·94	24·256	
,,		27	6·06	16·39	99·323	
,,		29	5·87	16·355	96·004	
			4)22·59		374·791	16·59
			5·65			
,,	August 1848.	25	7·05	18·335	129·262	
,,		27	2·47	20·625	50·944	
,,		29	2·57	20·575	52·878	
			3)12·09		233·084	19·28
			4·03			
4th	April 1848.	9	0·46	21·63	9·950	
,,		24	10·41	5·205	54·184	
,,		26	10·37	5·185	53·768	
,,		28	9·58	4·79	45·888	
,,		70	5·33	14·085	75·073	
,,		102	3·62	12·85	46·517	
,,		111	6·41	11·625	74·516	
,,		274	3·84	10·29	39·514	
,,		276	7·42	8·50	63·070	
,,		278	8·75	7·835	68·556	
,,		286	3·09	11·415	35·272	
,,		288	6·50	8·96	58·240	
,,		290	9·75	7·335	71·516	
			13)85·53		696·064	8·14
			6·579			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	May 1848.	24	2·88	11·85	33·128	
"		26	2·97	11·855	34·209	
"		28	3·45	11·305	39·002	
"		70	3·58	18·54	66·373	
"		102	0·56	14·94	8·367	
"		111	0·30	14·98	4·494	
"		214	14·25	7·125	101·531	
"		223	14·92	7·46	111·303	
"		274	5·54	14·98	82·989	
"		276	0·87	12·645	11·001	
"		278	0·37	12·395	4·586	
"		286	7·37	15·895	117·146	
"		288	5·87	15·145	88·901	
"		290	4·12	14·27	58·793	
			14)67·05		761·823	11·36
			4·79			
"	June 1848.	11	0·80	18·88	15·004	
"		13	3·04	14·26	43·351	
"		102	2·07	17·785	36·815	
"		111	4·28	18·80	80·464	
"		214	7·25	17·875	129·594	
"		223	6·58	18·21	119·822	
"		274	4·33	19·915	75·332	
"		276	9·00	17·58	158·220	
"		278	9·50	17·33	164·635	
"		286	2·50	20·83	52·075	
"		288	4·00	20·08	80·320	
"		290	5·75	19·205	110·429	
			12)59·10		1,066·061	18·04
			4·925			
"	July 1848.	11	2·58	20·57	53·071	
"		13	6·08	18·82	114·426	
"		24	4·77	15·675	74·770	
"		26	5·47	16·075	87·930	
"		28	5·62	15·84	89·021	
"		37	2·55	1·275	3·251	
"		38	2·67	1·335	3·564	
"		51	2·65	1·325	3·411	
"		52	1·43	0·715	1·022	
"		53	0·72	0·36	0·259	
"		54	0·70	0·35	0·245	
"		63	11·60	5·80	67·280	
"		67	0·78	0·39	0·304	
"		68	1·55	0·775	1·201	
"		79	8·92	16·40	146·288	
"		102	2·80	20·22	56·616	
"		111	0·92	21·40	19·688	
			17)61·81		722·347	11·69
			3·64			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	August 1848.	24	2·91	19·515	56·789	
"		26	3·05	20·335	62·022	
"		28	3·21	20·255	65·018	
"		37	9·79	7·445	72·886	
"		38	8·01	6·675	53·467	
"		51	6·61	5·955	39·362	
"		52	8·50	5·68	48·280	
"		53	6·54	3·99	26·095	
"		54	5·31	3·355	17·815	
"		67	6·56	4·06	26·633	
"		68	5·13	4·115	21·110	
"		69	6·26	3·13	19·594	
"		83	6·47	3·235	20·930	
"		84	4·59	2·295	10·534	
"		85	3·85	1·925	7·411	
"		99	3·93	1·965	7·722	
"		100	6·32	3·16	19·971	
			17)97·04		575·639	5·93
			5·71			
"	September 1848.	24	0·89	21·115	19·059	
"		37	3·19	13·935	44·453	
"		38	1·75	11·555	20·221	
"		49	7·00	3·500	24·500	
"		51	4·77	11·615	55·547	
"		52	3·58	11·720	41·957	
"		53	6·02	10·270	61·825	
"		54	4·77	8·395	40·044	
"		64	5·50	2·750	15·125	
"		65	6·00	3·000	18·000	
"		66	7·00	3·500	24·500	
"		67	5·11	9·895	50·563	
"		80	8·00	4·000	32·000	
"		81	7·68	3·8[illegible]	29·491	
"		82	5·33	2·665	14·204	
"		83	0·75	6·845	5·134	
"		86	10·16	5·080	51·613	
"		95	9·00	4·500	40·500	
"		96	8·10	4·050	32·805	
"		97	7·68	3·840	29·491	
"		98	8·39	4·195	35·196	
"		99	0·75	4·305	3·229	
"		102	0·16	21·270	3·403	
"		112	8·00	4·000	32·000	
"		113	8·00	4·000	32·000	
"		114	8·00	4·000	32·000	
"		130	8·00	4·000	32·000	
			27)153·58		820·860	5·34
			5·69			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	October 1848.	37	1·08	16·07	17·356	
"		49	1·30	7·65	9·945	
"		50	2·16	10·80	23·328	
"		51	3·08	15·57	47·956	
"		52	5·60	16·31	91·336	
"		53	2·58	14·67	37·848	
"		54	3·50	12·50	43·750	
"		64	3·18	7·09	22·546	
"		65	2·43	7·215	17·532	
"		66	1·43	7·715	11·032	
"		67	3·16	14·05	44·335	
"		68	6·31	9·835	62·059	
"		69	3·60	8·06	29·016	
"		80	1·68	8·84	14·851	
"		81	1·50	8·43	12·645	
"		82	3·10	6·88	21·328	
"		84	8·69	8·935	77·645	
"		85	3·18	5·41	17·200	
"		86	0·87	10·595	9·217	
"		95	2·20	10·100	22·220	
"		96	0·50	8·35	4·175	
"		97	0·75	8·055	6·041	
"		98	1·16	8·97	10·405	
"		99	0·72	5·04	3·629	
"		100	1·88	7·26	13·649	
"		102	0·51	21·605	11·018	
			26)66·15		682·162	10·31
			2·54			
"	November 1848.	37	1·24	17·23	21·365	
"		49	2·94	9·77	26·924	
"		50	7·59	5·955	45·198	
"		51	3·29	18·755	61·704	
"		52	1·29	19·755	25·484	
"		54	6·12	17·34	106·121	
"		65	3·54	10·2	36·108	
"		66	2·32	9·59	22·249	
"		68	2·86	14·42	41·241	
"		69	6·07	12·895	78·272	
"		81	0·98	9·670	9·477	
"		82	0·81	8·835	7·156	
"		85	5·31	9·685	51·427	
"		86	3·57	12·815	45·750	
"		99	6·20	8·500	52·100	
"		100	3·31	9·855	32·620	
"		63	1·42	12·31	17·480	
			17)58·86		680·676	11·56
			3·46			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	December 1848.	37	0·60	18·15	10·890	
"		49	3·27	15·875	51·911	
"		50	2·68	11·09	29·721	
"		65	3·71	13·825	51·291	
"		66	4·10	12·8	52·480	
"		69	0·85	17·355	14·752	
"		81	5·52	12·92	71·318	
"		83	0·81	7·625	6·176	
"		84	1·50	14·03	21·045	
"		85	2·94	13·81	40·601	
"		86	1·60	15·4	24·640	
"		99	0·10	11·65	1·165	
			12)27·68		375·990	13·59
			2·31			
"	January 1849.	37	1·10	19·0	20·900	
"		49	0·44	14·73	6·481	
"		50	2·27	13·565	30·792	
"		53	1·27	16·505	20·961	
"		64	5·44	11·4	62·016	
"		66	0·35	15·025	5·259	
"		67	1·52	16·37	24·882	
"		68	1·54	16·62	25·595	
"		69	1·23	17·395	21·396	
"		80	2·14	[illegible]	2·260	
"		82	4·63	11·555	53·500	
"		83	6·44	11·25	72·450	
"		84	1·44	15·5	22·320	
"		85	3·02	16·79	50·706	
"		86	0·61	16·505	10·068	
"		95	1·35	11·875	16·031	
"		96	1·19	9·195	10·942	
"		97	1·52	9·19	13·969	
"		98	0·99	10·045	9·945	
"		99	2·93	13·165	38·573	
"		101	5·72	2·86	16·359	
"		112	0·95	8·475	8·051	
"		114	0·20	8·1	1·620	
"		115	5·96	2·98	17·761	
"		116	6·96	3·48	24·221	
"		117	5·96	2·98	17·761	
"		130	1·28	8·64	11·059	
"		131	0·20	13·3	2·660	
"		132	1·66	13·99	23·223	
"		133	0·70	13·64	9·548	
			30)71·31		651·309	9·13
			2·38			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	February 1849.	63	3·95	14·995	58·480	
,,		64	2·08	15·16	31·532	
,,		67	0·75	17·505	13·287	
,,		68	0·41	17·595	7·216	
,,		80	1·91	13·075	24·973	
,,		82	1·33	14·535	19·331	
,,		83	0·08	14·51	11·608	
,,		85	0·30	18·45	5·535	
,,		86	0·99	17·305	17·131	
,,		95	3·84	13·47	51·599	
,,		96	3·83	11·705	18·042	
,,		97	1·75	10·825	36·972	
,,		98	1·33	11·205	14·902	
,,		99	2·34	15·8	38·972	
,,		101	1·93	6·685	12·902	
,,		112	0·83	9·365	7·772	
,,		113	1·87	8·965	16·864	
,,		114	4·17	10·285	42·888	
,,		115	1·58	6·75	10·665	
,,		116	0·58	7·25	4·205	
,,		117	1·08	6·5	7·020	
,,		131	1·92	14·36	27·571	
,,		132	4·00	16·82	67·28	
,,		133	4·83	16·405	79·236	
,,		148	10·13	5·245	51·592	
,,		198	10·01	5·005	50·100	
,,		207	10·85	5·425	58·861	
			27)78·97		790·124	10·00
			2·92			
,,	March 1849.	49	1·67	15·785	26·360	
,,		50	1·25	15·325	19·156	
,,		63	1·42	17·68	25·105	
,,		64	0·88	16·64	14·643	
,,		65	0·94	16·15	15·181	
,,		66	1·42	15·91	22·592	
,,		67	0·65	18·205	11·833	
,,		68	0·69	18·115	12·500	
,,		69	0·52	18·27	9·500	
,,		83	1·74	15·42	26·830	
,,		85	1·60	19·40	31·040	
,,		97	0·17	11·785	2·003	
,,		98	0·58	12·16	7·052	
,,		99	1·92	17·93	34·425	
,,		100	2·02	12·52	25·290	
,,		101	4·22	9·76	41·187	
,,		112	3·81	11·7	44·928	
,,		113	4·91	12·34	60·659	
,,		114	0·66	12·7	8·162	
,,		115	6·57	10·825	71·120	
,,		116	8·09	11·584	93·714	
,,		117	4·82	9·15	45·549	
,,		130	2·75	10·65	29·301	
,,		131	2·31	17·475	40·367	
4th	March 1849.	132	2·18	19·91	43·403	
,,		133	2·18	19·91	43·403	
,,		148	6·22	13·54	84·218	
,,		182	12·51	6·255	78·250	
,,		191	12·55	6·275	78·751	
,,		198	2·34	11·18	26·161	
,,		207	1·50	11·6	17·40	
			31)95·15		1091·403	11·47
			3·07			
,,	April 1849.	49	1·69	17·465	29·516	
,,		50	1·78	16·94	30·153	
,,		63	1·06	18·92	20·055	
,,		64	2·48	18·32	45·433	
,,		65	0·52	16·88	8·778	
,,		66	0·40	18·83	0·753	
,,		67	0·21	18·65	3·876	
,,		68	0·20	18·59	3·718	
,,		69	1·20	19·13	22·956	
,,		85	0·11	20·255	2·228	
,,		86	1·18	18·39	21·700	
,,		95	0·69	16·735	11·547	
,,		99	0·21	18·995	3·989	
,,		100	1·28	14·17	18·138	
,,		101	2·27	13·005	29·521	
,,		113	1·23	15·405	18·948	
,,		114	1·41	13·735	19·366	
,,		115	1·63	13·215	21·540	
,,		116	1·23	16·215	19·944	
,,		118	2·18	19·16	18·260	
,,		130	1·98	13·52	26·769	
,,		131	0·45	17·875	8·043	
,,		148	4·31	18·32	81·675	
,,		198	7·46	16·08	119·956	
,,		207	6·29	15·495	97·463	
,,		230	14·03	7·015	98·420	
,,		239	14·03	7·015	98·420	
			27)71·85		918·480	12·78
			2·66			
,,	May 1849.	118	0·30	20·85	6·255	
,,		182	8·75	16·885	147·743	
,,		191	8·71	16·905	147·242	
,,		198	1·33	20·475	27·232	
,,		207	2·50	19·89	49·725	
,,		230	7·37	17·715	130·560	
,,		239	7·37	17·715	130·560	
,,		246	14·86	7·43	110·410	
,,		255	15·40	7·70	118·580	
			9)66·59		868·303	13·0[illegible]
			7·40			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block	Product.	Mean depth at which sinking was performed struck on whole class.
4th.	June 1849.	80	0·16	14·11	2·258	
,,		82	0·25	15·325	3·831	
,,		96	0·08	13·66	1·093	
,,		100	0·74	15·18	11·233	
,,		101	0·61	14·445	8·811	
,,		246	6·41	18·165	116·437	
,,		255	5·87	18·335	107·626	
			7)14·12		251·289	17·79
			2·02			
,,	July 1849.	80	1·96	15·17	29·733	
,,		81	1·60	16·38	26·208	
,,		82	0·87	15·885	13·820	
,,		96	1·28	14·34	18·355	
,,		100	5·62	15·761	88·577	
,,		101	1·60	15·55	24·880	
,,		112	0·78	13·91	10·850	
,,		130	1·80	15·41	27·738	
			8)15·51		240·161	15·48
			1·94			
,,	August 1849.	80	1·04	16·67	17·337	
,,		81	2·16	18·36	39·658	
,,		82	0·88	16·76	14·749	
,,		96	0·76	15·36	11·674	
,,		[illegible]	0·71	21·475	15·247	
,,		101	1·19	16·945	20·164	
,,		112	1·67	15·235	25·442	
,,		113	0·03	16·035	0·481	
,,		130	2·01	17·315	34·803	
			9)10·45		179·555	17·18
			1·16			
,,	September 1849.	80	2·37	18·375	43·549	
,,		81	1·86	20·37	37·888	
,,		82	3·86	19·13	73·842	
,,		96	0·16	15·82	2·531	
,,		101	2·50	18·79	46·975	
,,		112	4·76	18·45	87·822	
,,		113	2·30	17·2	39·560	
,,		115	3·00	17·22	51·660	
,,		130	2·50	19·57	48·925	
			9)23·31		432·752	18·56
			2·59			
,,	October 1849.	80	2·20	20·66	45·452	
,,		82	0·94	21·53	20·238	
,,		96	0·18	15·99	2·878	
,,		101	1·48	20·76	30·754	
,,		113	1·65	19·175	31·639	
,,		115	2·44	19·95	48·654	
,,		130	1·18	21·41	25·264	
			7)10·07		204·879	20·34
			1·44			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
5th	Novr. 1849.	147	11·05	5·52		5·52
,,	December 1849.	147	6·56	14·33	94·005	
,,		149	12·93	6·465	83·592	
,,		150	13·09	6·545	85·675	
,,		163	12·38	6·19	76·632	
,,		164	12·67	6·335	80·264	
,,		165	12·84	6·42	82·433	
,,		166	13·05	6·525	85·151	
,,		179	12·63	6·315	79·758	
,,		180	13·01	6·505	84·630	
			9)109·16		752·140	6·89
			12·13			
,,	January 1850.	147	4·85	20·035	97·170	
,,		149	7·68	16·77	128·793	
,,		150	9·35	17·765	166·103	
,,		163	8·23	16·495	135·754	
,,		164	8·64	16·99	146·793	
,,		165	9·60	17·64	169·344	
,,		166	9·30	17·745	165·625	
,,		179	8·68	16·97	147·300	
,,		180	9·43	17·775	167·618	
			9)75·85		1,325·500	17·48
			8·43			
,,	February 1850.	149	1·83	21·525	39·391	
,,		163	1·83	21·525	39·391	
,,		164	1·02	21·82	22·256	
,,		179	1·83	21·525	39·391	
			4)6·51		140·429	21·57
			1·63			
,,	April 1850.	127	12·71	Mean depth is half of total depth.	80·772	
,,		128	11·30		63·845	
,,		129	11·66		67·978	
,,		143	11·94		71·282	
,,		144	10·64		56·605	
,,		145	9·81		48·118	
,,		146	10·53		55·440	
,,		159	12·12		73·448	
,,		160	11·30		63·845	
,,		161	11·10		61·605	
,,		162	11·02		60·720	
,,		176	10·39		53·976	
,,		177	11·04		60·941	
,,		178	10·41		54·184	
,,		192	11·73		68·796	

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on which [illegible]
4th	April 1850.	193	11·91	Mean depth is half of total depth.	69·738	
,,		194	10·47		54·810	
,,		208	10·85		58·861	
,,		209	11·58		67·048	
,,		210	11·60		67·280	
,,		224	10·51		55·238	
,,		225	10·68		57·031	
,,		226	11·71		68·562	
,,		240	10·08		50·803	
,,		241	10·47		54·810	
,,		242	9·68		45·351	
,,		256	10·04		50·401	
,,		257	10·43		54·362	
,,		258	9·93		49·302	
,,		271	8·77		38·456	
,,		272	9·58		45·888	
			31,335·89		1,831·018	5·45
			10·84			
,,	May 1850.	127	3·63	14·525	52·726	
,,		128	1·82	12·21	22·223	
,,		129	0·26	11·79	3·065	
,,		141	2·23	11·755	26·211	
,,		145	1·15	10·385	11·943	
,,		146	3·26	10·693	34·859	
,,		150	3·98	13·93	55·441	
,,		160	2·82	12·71	35·842	
,,		161	3·35	12·775	42·796	
,,		162	3·35	12·695	42·528	
,,		175	1·13	12·685	14·334	
,,		176	3·31	12·045	39·869	
,,		177	3·26	12·67	41·304	
,,		178	3·13	11·975	37·182	
,,		192	1·39	12·425	17·271	
,,		193	1·91	12·88	24·987	
,,		194	2·73	11·835	32·310	
,,		208	1·91	11·82	22·030	
,,		209	1·17	12·165	14·233	
,,		210	1·03	12·115	12·145	
,,		224	3·03	12·025	36·435	
,,		225	3·11	12·235	38·051	
,,		226	1·16	12·20	14·186	
,,		240	3·00	11·58	34·740	
,,		241	2·45	11·695	27·653	
,,		242	3·28	11·32	37·129	
,,		256	1·58	10·83	17·111	
,,		257	1·11	10·985	12·193	
,,		258	2·82	11·34	31·979	
,,		271	2·77	10·155	28·129	
,,		272	1·88	10·52	19·777	
			31 /73·07		881·855	12·07
			2·36			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on which [illegible]
4th	June 1850.	127	2·23	17·175	35·925	
,,		128	3·90	15·07	58·773	
,,		129	4·84	14·34	69·406	
,,		141	2·88	14·31	41·213	
,,		146	4·94	16·26	80·324	
,,		150	2·48	17·16	42·557	
,,		160	3·74	15·99	59·[illegible]	
,,		161	4·67	16·785	78·386	
,,		162	4·75	16·715	79·[illegible]	
,,		175	5·32	15·94	84·801	
,,		176	4·11	15·755	64·753	
,,		177	4·82	16·71	80·542	
,,		178	5·06	16·47	83·338	
,,		184	12·00	6·00	72·000	
,,		192	5·30	15·77	83·581	
,,		193	5·37	16·135	86·645	
,,		194	5·47	15·935	87·164	
,,		195	11·17	5·585	62·384	
,,		196	12·17	6·085	74·054	
,,		197	15·13	7·565	114·458	
,,		208	2·58	14·035	35·559	
,,		209	5·33	15·415	82·162	
,,		210	5·35	15·305	81·882	
,,		211	15·63	7·815	122·148	
,,		212	16·46	8·23	135·466	
,,		213	18·21	9·105	165·802	
,,		224	4·86	15·97	77·614	
,,		225	5·07	16·325	82·768	
,,		226	5·03	15·485	77·890	
,,		227	17·09	8·545	146·034	
,,		228	16·92	8·46	143·143	
,,		229	16·46	8·23	135·466	
,,		240	5·52	15·84	87·437	
,,		241	5·68	15·76	89·517	
,,		242	5·02	15·47	77·659	
,,		243	17·75	8·875	157·531	
,,		244	18·88	9·44	178·227	
,,		245	18·46	9·23	170·386	
,,		256	6·19	11·865	96·474	
,,		257	6·44	14·76	95·054	
,,		258	5·42	15·46	83·793	
,,		259	18·34	9·17	168·178	
,,		260	18·63	9·315	173·538	
,,		271	6·40	14·74	94·336	
,,		272	4·19	13·555	56·795	
			45/386·51		1,256·428	11·03
			8·59			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	July 1850.	195	6·08	14·21	56·397	
"		196	5·62	14·98	84·187	
"		197	3·54	16·90	59·826	
"		211	2·87	17·065	48·976	
"		212	2·37	17·645	41·819	
"		213	1·29	18·855	24·323	
"		227	1·99	18·085	35·989	
"		228	2·58	18·21	46·982	
"		229	3·04	17·98	54·659	
"	July 1850.	243	1·75	18·625	32·594	
"		244	0·28	19·02	5·325	
"		245	1·04	19·00	19·760	
"		259	1·16	18·92	21·947	
"		260	0·87	19·065	16·587	
"		181	6·00	15·000	90·000	
			15)40·48		669·371	16·53
			2·69			

A. G. GOODWYN, *Lieutenant,*

Exec. Engr. No. Do. Ganges Canal.

Tabular Statement of the Cost of Undersinking Foundation Blocks of the Solani Aqueduct from 1st April 1848, to 1st November 1850.

Date of Sinking.	Class of Blocks.	Detail of Blocks worked at, [illegible] numbered [illegible] plan of Aqueduct Foundations.	Mean superficial area embraced by circumference of lines of Blocks.	Arithmetical mean depth at which sinking was performed.	Mean monthly progress.	Cost of Undersinking. Labour.	Cost of Undersinking. Materials.	Cost of Undersinking. Tools and Sundries.	Cost of Undersinking. Total.	Removing Sand from Blocks. Labour.	Removing Sand from Blocks. Tools and Sundries.	Removing Sand from Blocks. Total.	Grand Total expense of entire operation.	Rate per running foot, on whole class, for mean depth at which sinking was performed.	Rate per sq. ft. of area as detailed in 4th column, undersunk mean monthly progress of blocks, at mean depth noted in 5th column.	Rate per sq. ft. of area, as detailed in 4th column, undersunk one foot, at mean depth noted in 5th column.
			sq. feet.	feet.	feet.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	ANNAS.
April 1848.	1st	Nos. 22, 23, 261* to 263,* and 268 to 270, ...	524·15	7·12	4·51	151 5 4	17 8 11	34 7 7	203 5 10	153 14 11	7 4 4	161 3 3	364 9 1	10 1 9	,, 1 5	·3141
May ,,	,,	Nos. 23, and 261 to 270, ...	554·02	15·95	7·25	935 14 11	153 2 0	34 7 8	1,123 8 7	691 12 4	7 4 5	699 0 9	1,822 9 4	22 13 6	,, 4 9	·6552
June ,,	,,	Nos. 15 to 22, and 261 [illegible] 269, ...	568·77	14·06	2·95	623 6 6	93 [illegible] 2	34 7 7	751 1 3	351 5 11	7 4 4	358 10 3	1,109 11 6	23 14 0	,, 1 10	·6214
July ,,	,,	Nos. 14 to 23, ...	570·51	16·14	4·79	378 4 8	54 4 10	34 7 7	467 1 1	257 7 10	7 4 4	264 12 2	731 13 3	15 4 6	,, 2 1	·4245
August ,,	,,	Nos. 14 and 16 to 23, ...	546·04	17·03	3·14	405 11 11	86 12 0	15 11 2	508 3 1	236 8 4	7 1 5	243 9 9	751 12 10	26 9 2	,, 2 5	·7696
September	,,	Nos. 14 and 17 to 23, ...	541·23	20·36	1·80	318 1 0	67 10 1	15 11 2	401 6 3	167 9 1	7 1 4	174 10 5	576 0 8	40 6 0	,, 2 2	1·2037
October ,,	,,	No. 14, ...	500·00	20·72	2·27	34 1 1	3 1 9	15 11 2	52 14 0	16 0 0	7 1 4	23 1 4	75 15 4	38 7 4	,, 2 5	1·0646
April 1848.	2nd	Nos. 7, 30, 31, 103, 104, 106 to 110, 279, 280, 292 & 293.	385·88	8·95	7·62	417 10 1	45 7 10	43 2 10	506 4 9	371 3 9	10 4 11	381 8 8	887 13 5	8 5 2	,, 2 7	·3390
May ,,	,,	Nos. 30, 31, 103 to 110, 215 to 222, 279, 280, 292 & 293.	421·13	9·36	6·72	784 9 9	158 11 [illegible]	43 2 10	986 8 3	771 1 7	10 [illegible] 0	781 6 7	1,767 14 10	11 15 4	,, 3 1	·1585
June ,,	,,	Nos. 103 to 110, 215 to 222, 279, 280, 292 and 293,	433·24	17·95	5·05	1,093 9 1	155 6 6	43 2 11	1,292 2 6	714 12 3	10 4 11	725 1 2	2,017 3 8	19 15 3	,, 3 9	·7426
July ,,	,,	Nos. 30, 31, 103, and 105 to 110, ...	401·70	18·30	1·67	308 13 11	47 9 10	43 2 10	399 10 7	204 9 9	10 4 11	214 14 8	614 9 [illegible]	40 14 8	,, 2 9	1·6431
August ,,	,,	Nos. 30 and 31, ...	360·00	18·96	3·48	116 4 1	13 0 9	10 3 9	139 8 7	70 0 6	5 4 7	75 5 1	214 13 8	30 13 2	,, 4 9	1·3649
September	,,	Nos. 30, 31, and 87 to 94, ...	437·38	5·27	7·49	294 1 7	45 0 3	10 3 9	349 5 7	165 13 3	5 4 8	171 1 11	520 7 6	6 15 2	,, 1 11	·2550
October ,,	,,	Nos. 90 to 94, ...	440·00	9·12	3·22	116 12 11	12 11 0	10 3 10	139 11 9	74 0 0	5 4 7	79 4 7	219 0 4	19 9 8	,, 1 7	·4917
November	,,	Nos. 87 to 90, ...	440·00	12·36	2·32	45 2 6	3 13 5	9 0 1	58 0 0	31 10 3	3 14 11	35 9 2	93 [illegible] 2	10 1 2	,, ,, 10	·3592
December	,,	Nos. 87 to 92, ...	440·00	15·14	5·16	248 12 8	43 6 7	9 0 1	301 3 4	201 4 1	3 15 0	205 3 1	506 6 5	16 5 7	,, 3 1	·5975
Jany. 1849.	,,	Nos. 87 to 94, ...	440·00	16·27	2·81	302 1 4	140 9 2	9 0 2	451 10 8	234 6 10	3 15 0	238 5 10	690 0 6	30 11 7	,, 3 2	1·1269
February	,,	Nos. 87, 90, to 94, and 199 to 206, ...	440·00	6·39	6·35	462 10 7	216 13 8	8 12 5	688 4 8	361 0 7	7 7 0	368 7 7	1,056 12 [illegible]	11 14 0	,, 2 9	·4331
March ,,	,,	Nos. 91 to 93, 183 to 190, and 199 to 206, ...	440·00	7·09	6·22	468 12 10	167 13 4	8 12 4	645 6 6	678 13 5	7 7 0	686 4 5	1,331 10 11	11 4 3	,, 2 5	·3885
April ,,	,,	Nos. 126, 183, 185, 199 to 206, and 231 to 238, ..	440·00	9·93	8·97	942 4 5	220 12 5	33 3 10	1,205 4 8	930 10 8	21 2 2	951 12 10	2,157 1 6	12 10 5	,, 4 2	·4645
May ,,	,,	Nos. 126, 183 to 190, 199 to 206, 231 to 238, & 247 to 254.	440·00	13·00	7·78	1,5[illegible] 7 10	489 1 7	33 3 11	2,051 13 4	1,346 8 11	21 2 2	1,367 11 1	3,419 8 5	13 5 3	,, 3 0	·4820
June ,,	,,	Nos. 126, 188 to 190, 233, and 247 to 254, ...	440·00	17·88	4·67	574 7 6	147 5 3	33 3 9	755 0 6	259 0 6	21 2 2	280 2 8	1,036 3 2	17 0 9	,, 2 11	·6245
April 1848.	3rd	Nos. 25, 27, 29, 273, 275, 277, 287, 289, and 291, ..	336·00	6·50	10·57	286 8 0	[illegible] 5 3	9 6 9	315 4 0	241 8 5	3 5 10	244 14 3	561 2 3	5 14 5	,, 3 0	·2838
May ,,	,,	Nos. 25, 27, 29, 273, 275, 277, 287, 289, and 291, ..	336·00	15·28	5·00	341 12 10	30 15 8	9 6 9	382 3 3	233 11 10	3 5 9	237 1 7	619 4 10	13 12 1	,, 3 3	·6500
June ,,	,,	Nos. 12, 273, 275, 277, 287, and 291, ...	336·00	19·58	3·44	251 15 6	44 9 4	9 6 9	305 15 7	137 13 5	3 5 9	141 3 2	447 2 9	21 10 10	,, 3 6	·0174
July ,,	,,	Nos. 12, 25, 27, and 29, ...	336·00	16·59	5·65	94 14 10	10 15 11	9 6 8	115 5 5	58 14 10	3 5 9	62 4 7	177 10 0	7 13 10	,, 2 1	·3687
August ,,	,,	Nos. 25, 27, and 29, ...	336·00	19·28	4·03	146 5 9	13 11 4	8 4 0	168 5 1	91 12 5	4 11 5	96 7 10	264 12 11	21 14 5	,, 4 2	1·0323
April 1848.	4th	Nos. 9, 24, 26, 28, 70, 102, 111, 274, 276, 278, 286, 288 and 290, ...	184·61	8·14	6·58	192 9 1	13 6 2	12 2 4	218 1 7	209 14 11	4 12 5	214 11 4	432 12 11	5 1 0	,, 2 11	·4432
May ,,	,,	Nos. 24, 26, 28, 70, 102, 111, 214, 223, 274, 276, 278, 286, 2[illegible] and 290.	174·96	11·36	4·79	279 7 3	30 2 0	12 2 4	321 11 7	245 3 1	4 12 6	249 15 7	571 11 2	8 8 5	,, 3 9	·7829
June ,,	,,	Nos. 11, 13, 102, 111, 214, 223, 274, 276, 278, 286, 288 and 290, ...	179·79	18·04	4·62	481 12 10	55 1 6	12 2 5	519 0 9	290 3 8	4 12 6	295 0 2	814 ,, 11	14 4 6	,, 6 6	1·3211
July ,,	,,	Nos. 11, 13, 24, 26, 28, 37, 38, 51 to 54, 63, 67, 68, 79, 102 and 111, ...	163·7	11·69	3·61	269 3 4	38 11 7	12 2 4	320 1 3	210 10 7	4 12 6	215 7 1	535 8 4	8 10 7	,, 3 1	·8471
August ,,	,,	Nos. 24, 26, 28, 37, 38, 51 to 54, 67 [illegible] 69, 83 to 85, 99 and 100, ...	124·73	5·93	5·71	278 8 8	44 0 8	18 13 1	341 6 5	201 9 2	12 13 10	214 7 0	555 13 5	5 11 [illegible]	,, 4 2	·7297
September	,,	Nos. 24, 37, 38, 49, 51 to 54, 64 to 67, 80 to 83, 86, 95 to 99, 102, 112 to 114 and 130, ...	122·05	5·34	5·69	338 13 4	47 8 1	18 13 1	405 2 6	257 4 3	12 13 10	270 2 1	675 4 9	4 6 4	,, 3 3	·5715
October	,,	Nos. 37, 49 to 54, 64 to 69, 80 to 82, 84 to 86, 95 to 100 and 102, ...	114·22	10·31	2·54	369 5 3	38 6 8	18 13 2	426 9 1	293 4 4	12 13 11	306 2 3	732 11 4	11 1 3	,, 3 11	1·5419
November	,,	Nos. 37, 49 [illegible] 52, 54, 63, 65, 66, 68, 69, [illegible], 82, 85, 86, 99 and 100, ...	125·05	11·56	3·46	273 14 7	49 12 7	[illegible] [illegible] 1	332 11 3	181 1 8	5 9 3	186 13 11	519 9 2	8 13 3	,, 3 11	1·132
December	,,	Nos. 37, 49, 50, 65, 66, 69, 81, 83 to 86 and 99, ..	115·40	13·59	2·31	207 14 5	33 2 1	9 0 1	250 0 7	173 9 1	5 9 3	179 2 4	429 2 11	15 7 11	,, 4 11	2·1284
Jany. 1849.	,,	Nos. 37, 49, 50, 53, 64, 66 to 69, 80, 82 [illegible] 86, 95 to 99, 101, 112, 114 to 117 and 130 to 133, ..	114·15	9·13	2·38	375 7 2	140 10 10	9 0 2	525 2 2	314 6 7	5 9 3	319 15 10	845 2 0	11 12 11	,, 3 11	1·6456
February	,,	Nos. 63, 64, 67, 68, 80, 82, 83, 85, 86, 95 to 99, 101, 112 to 117, 131 to 133, 148, 198 and 207, ..	138·74	10·09	2·92	476 4 6	95 14 10	8 4 3	580 7 7	377 14 10	6 4 6	384 3 4	964 10 11	12 3 5	,, 4 1	1·3984
March ,,	,,	Nos. 49, 50, 63 to 69, 83, 85, 97 [illegible] 101, 112 [illegible] 117, 130 to 133, 148, 182, 191, 198, and 207, ..	131·11	11·47	3·07	594 6 11	107 0 6	8 4 4	709 11 5	603 1 0	6 4 7	609 5 7	1,319 1 [illegible]	13 13 10	,, 5 2	1·6829
April ,,	,,	Nos. 49, 50, 63 to 69, 85, 86, 95, 99 to 101, 113 to 116, 118, 130, 131, 148, 198, 207, 230 and 239,	148·30	12·78	2·66	405 10 9	83 7 11	7 4 1	496 6 9	345 4 0	4 0 1	349 4 1	845 10 10	11 12 4	,, 3 5	1·2845
May ,,	,,	Nos. 118, 182, 191, 198, 207, 230, 239, 246 and 255,	160·00	13·40	7·40	210 3 6	80 9 10	7 4 1	298 1 5	145 15 3	4 0 0	149 15 3	448 0 [illegible]	6 11 8	,, 5 0	·6757
June ,,	,,	Nos. 80, 82, 96, 100, 101, 246 and 255, ...	153·30	17·79	2·02	239 14 8	80 15 7	7 4 1	228 2 4	68 1 7	4 0 0	72 1 7	300 3 11	21 4 3	,, 5 5	2·6815
July ,,	,,	Nos. [illegible] to 82, 96, 100, 101, 112 and 130, ...	107·43	15·48	1·94	151 14 0	74 12 1	7 4 1	233 14 2	95 1 7	4 0 0	[illegible] 1 7	332 15 9	21 7 6	,, 6 2	3·1756
August ,,	,,	Nos. 80 to 82, 96, 100, 101, 112, 113 and 130, ..	112·50	17·18	1·16	151 13 7	100 11 6	3 0 1	258 9 2	139 9 6	3 0 3	142 9 9	401 2 11	38 7 3	,, 6 4	5·1597
September	,,	Nos. 80 to 82, 96, 101, 112, 113, 115 and 130, ..	115·18	18·56	2·59	210 13 11	50 5 7	3 0 0	264 3 6	125 2 2	3 0 4	128 2 6	392 6 0	16 13 4	,, 6 1	2·3480
October	,,	Nos. 80, 82, 96, 101, 113, 115 and 130, ...	115·58	20·34	1·44	101 1 2	47 13 8	3 0 0	151 14 10	66 12 2	3 0 4	69 12 6	221 11 4	22 0 3	,, 4 5	3·0668
November	,,	No. 147, ...	220·00	5·52	11·05	15 4 10	12 8 2	5 3 3	33 0 3	57 9 7	5 9 6	63 3 1	96 [illegible] 4	8 11 4	,, 7 0	·6335
December	,,	Nos. 147, 149, 150, 163 to 166, 179 and 180, ..	193·99	6·89	12·13	155 10 11	68 15 7	5 3 3	229 13 9	158 7 4	5 9 7	164 0 11	393 14 8	3 9 9	,, 3 7	·2946
Jany. 1850.	,,	Nos. 147, 149, 150, 163 to 166, 179 and 180, ..	193·38	17·48	8·43	203 10 4	90 3 3	5 3 3	299 0 10	363 12 11	5 9 7	369 [illegible] 6	668 7 [illegible]	8 13 0	,, 6 2	·7315
February	,,	Nos. 149, 163, 164 and 179, ...	212·24	21·57	1·63	50 1 1	15 11 10	13 2 0	78 14 11	117 13 5	17 0 7	134 14 0	213 12 11	32 13 6	,, 4 0	2·4539
April ,,	,,	Nos. 127 to 129, 143 [illegible] 146, 159 to 162, 176 to 178, 192 to 194, 208 to 210, 224 to 226, 240 to 242, 256 to 258, 271 and 272, ...	200·40	5·45	10·84	672 7 5	206 14 9	13 2 1	892 8 3	1,086 6 8	17 0 8	1,103 7 4	1,995 15 7	5 15 1	,, 5 2	·4765
May ,,	,,	Nos. 127 to 129, 144 to 146, 159 to 162, 175 to 178, 192 to 194, 208 to 210, 224 to 226, 240 to 242, 256 to 258, 271 and 272, ...	202·52	12·07	2·36	352 6 0	213 10 7	71 8 7	637 9 2	585 1 6	28 13 11	613 15 5	1,251 [illegible] 7	17 2 1	,, 3 2	1·3381
June ,,	,,	Nos. 127 to 129, 144, 146, 159 to [illegible]2, 175 to 178, 181, 192 to 197, 208 [illegible] 213, 224 to 229, 240 [illegible] 245, 256 to 260, 271 and 272, ...	208·17	11·03	8·59	1,872 15 [illegible]	463 0 6	71 8 7	2,407 8 6	1,606 4 3	28 13 11	1,635 2 2	4,042 10 8	10 12 8	,, 7 1	·8246
July ,,	,,	Nos. 181, 195 to 197, 211 to 213, 227 to 229, 243 to 245, 259 and 260.	208·11	16·53	2·70	277 10 10	16 2 9	71 8 9	365 6 4	227 9 0	28 13 11	256 6 11	621 13 3	18 0 7	,, 3 2	1·1726

* Both 261 and [illegible] included, [illegible] "To" bears this meaning throughout the column.

N. B. From 1st April to [illegible] November 1848, the pay of bildars was Rs. [illegible] per mensem; 4 bildars were employed working each jham and 3½ removing sand brought up by each jham. On 1st November 1848, the pay of bildars was reduced to Rs. 3-8. On 1st December 1848, the number of men working each jham was reduced [illegible] 3, with 3 [illegible] removing sand. The latter number was again reduced about [illegible] months later [illegible] 2½. This statement, however, as far as the removal of sand is concerned, must [illegible] received with caution, as, under particular circumstances, the number of men, thus employed, varied so considerably as to [illegible] beyond description in any general notice like the present.

Roorkee, 26th August 1851.

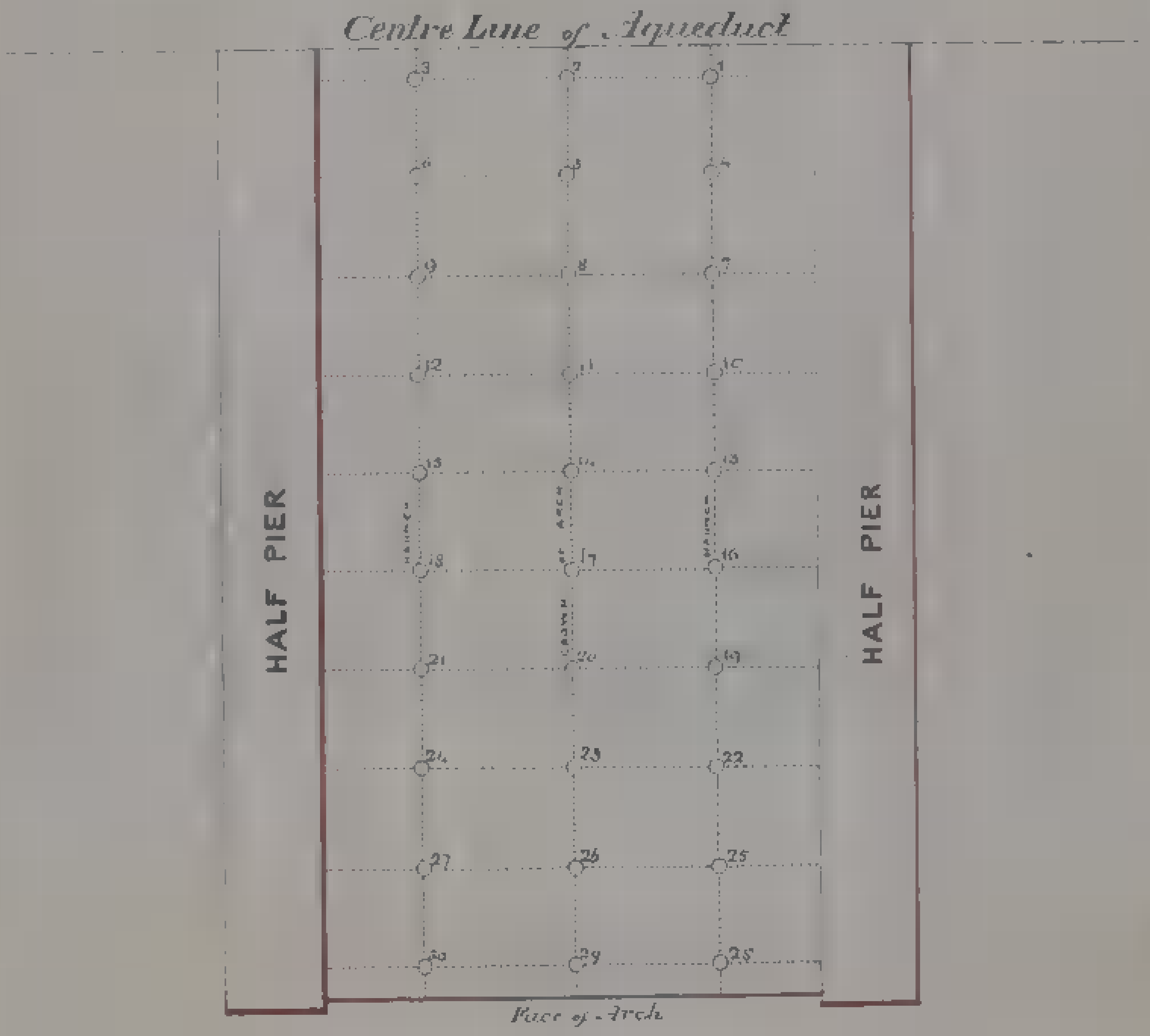
A. GOODWYN, Lieut.
Executive Engineer Northern Division Ganges Canal.

lio 7 6/-

APPENDIX
P

PLAN

Shewing the points on the Haunches and Crown of the Solano Aqueduct Arches at which the Amount of Depression was Measured.



Report of Sinking in the Arches of the Solani Aqueduct.

No. 1 Arch Points	Sinking	No. 2 Arch Points	Sinking	No. 3 Arch Points	Sinking	No. 4 Arch Points	Sinking	No. 5 Arch Points	Sinking
1	0.095	1	0.115	1	0.145	1	0.090	1	0.140
2	0.200	2	0.215	2	0.265	2	0.180	2	0.225
3	0.110	3	0.115	3	0.160	3	0.085	3	0.105
4	0.105	4	0.085	4	0.155	4	0.040	4	0.120
5	0.175	5	0.195	5	0.270	5	0.180	5	0.140
6	0.095	6	0.110	6	0.160	6	0.045	6	0.200
7	0.005	7	0.045	7	0.145	7	0.045	7	0.115
8	0.175	8	0.185	8	0.265	8	0.175	8	0.185
9	0.095	9	0.005	9	0.150	9	0.095	9	0.085
10	0.110	10	0.185	10	0.145	10	0.095	10	0.125
11	0.175	11	0.185	11	0.250	11	0.175	11	0.175
12	0.095	12	0.100	12	0.155	12	0.095	12	0.080
13	0.110	13	0.090	13	0.155	13	0.095	13	0.115
14	0.175	14	0.190	14	0.260	14	0.175	14	0.165
15	0.095	15	0.095	15	0.160	15	0.095	15	0.080
16	0.105	16	0.090	16	0.165	16	0.095	16	0.105
17	0.185	17	0.185	17	0.280	17	0.175	17	0.160
18	0.095	18	0.105	18	0.170	18	0.095	18	0.085
19	0.110	19	0.105	19	0.165	19	0.095	19	0.110
20	0.190	20	0.205	20	0.285	20	0.170	20	0.180
21	0.095	21	0.115	21	0.150	21	0.095	21	0.095
22	0.115	22	0.095	22	0.170	22	0.090	22	0.125
23	0.200	23	0.200	23	0.280	23	0.175	23	0.200
24	0.105	24	0.105	24	0.140	24	0.090	24	0.100
25	0.120	25	0.085	25	0.165	25	0.095	25	0.120
26	0.205	26	0.195	26	0.250	[illegible]	0.185	26	0.215
27	0.100	27	0.110	27	0.170	27	0.090	27	0.110
28	0.135	28	0.100	28	0.160	28	0.105	28	0.140
29	0.225	29	0.185	29	0.270	29	0.195	29	0.235

Averages:
- No. 1 Arch: Haunches, average sinking of 20 Points 0.1005; Crown do 10 " 0.1905
- No. 2 Arch: Haunches, average sinking of 20 Points 0.0955; Crown do 10 " 0.1940
- No. 3 Arch: Haunches, average sinking of 20 Points 0.1605; Crown do 10 " 0.2710
- No. 4 Arch: Haunches, average sinking of 20 Points 0.0933; Crown do 10 " 0.1785
- No. 5 Arch: Haunches, average sinking of 20 Points 0.1135; Crown do 10 " 0.1930

No. 6 Arch Points	Sinking	No. 7 Arch Points	Sinking	No. 8 Arch Points	Sinking	No. 9 Arch Points	Sinking	No. 10 Arch Points	Sinking
1	0.165	1	0.235	1	0.085	1	0.000	1	0.070
2	0.250	2	0.340	2	0.165	2	0.120	2	0.180
3	0.140	3	0.205	3	0.090	3	[illegible]	3	0.105
4	0.165	4	0.230	4	[illegible].090	4	0.080	4	0.080
5	0.235	5	0.320	5	0.165	5	0.140	5	0.180
6	0.130	6	0.190	6	0.090	6	0.095	6	0.100
7	0.160	7	0.230	7	0.085	7	0.090	7	0.078
8	0.235	8	0.315	8	0.160	8	0.140	8	0.160
9	0.130	9	0.200	9	0.095	9	0.090	9	0.100
10	0.165	10	0.220	10	0.095	10	0.075	10	0.084
11	0.240	11	0.315	11	0.160	11	0.135	11	0.180
12	0.135	12	0.200	12	0.100	12	0.070	12	0.100
13	0.160	13	0.225	13	0.090	13	0.090	13	0.062
14	0.155	14	0.315	14	0.160	14	0.140	14	0.180
15	0.105	15	0.140	15	0.100	15	0.040	15	0.066
16	0.165	16	0.215	16	[illegible].095	16	0.085	16	0.090
17	[illegible].255	17	0.310	17	0.155	17	0.135	17	0.190
18	0.150	18	0.190	18	0.095	18	0.085	18	0.105
19	0.160	19	0.225	19	[illegible].095	19	0.075	19	0.089
20	0.250	20	0.310	20	0.165	20	0.135	20	0.200
21	0.150	21	0.195	21	0.095	21	0.035	21	0.160
22	0.170	22	0.220	22	0.095	22	0.100	22	0.078
23	0.260	23	0.320	23	0.160	23	0.140	23	0.190
24	0.145	24	0.200	24	0.045	24	0.090	24	0.110
25	0.190	25	0.220	25	0.165	25	0.040	25	0.078
26	0.280	26	0.320	26	0.170	26	0.160	26	0.200
27	0.160	27	0.210	27	0.105	27	0.000	27	0.110
28	0.200	28	0.215	28	0.115	28	0.100	28	0.069
29	0.315	29	0.315	29	0.140	29	0.175	29	0.200
30	0.170	30	0.210	30	0.115	30	0.090	30	0.110

Averages:
- No. 6 Arch: Haunches, average sinking of 20 Points 0.1552; Crown do 10 " 0.2475
- No. 7 Arch: Haunches, average sinking of 20 Points 0.2115; Crown do 10 " 0.3180
- No. 8 Arch: Haunches, average sinking of 20 Points 0.0965; Crown do 10 " 0.1650
- No. 9 Arch: Haunches, average sinking of 20 Points 0.0870; Crown do 10 " 0.1445
- No. 10 Arch: Haunches, average sinking of 20 Points 0.0995; Crown do 10 " 0.1845

Report of Sinking in the Arches of the Solani Aqueduct

Level Point	No 11 Arch Sinking	No 11 Arch Average	Level Point	No 12 Arch Sinking	No 12 Arch Average	Level Point	No 13 Arch Sinking	No 13 Arch Average	Level Point	No 14 Arch Sinking	No 14 Arch Average	Level Point	No 15 Arch Sinking	No 15 Arch Average
1	0·100	Haunches. Average Sinking 0·1029	1	0·060	Haunches. Average Sinking 0·0760	1	0·049	Haunches. Average Sinking 0·0502	1	0·076	Haunches. Average Sinking 0·0765	1	0·083	Haunches. Average Sinking 0·0832
2	0·192	Crown do 0·1987	2	0·120	Crown do 0·1290	2	0·129	Crown do 0·1290	2	0·142	Crown do 0·1419	2	0·153	Crown do 0·1630
3	0·110		3	0·065		3	0·051		3	0·078		3	0·076	
4	0·100		4	0·065		4	0·050		4	0·076		4	0·082	
5	0·200		5	0·120		5	0·126		5	0·141		5	0·152	
6	0·190		6	0·070		6	0·052		6	0·079		6	0·085	
7	0·094		7	0·080		7	0·048		7	0·075		7	0·090	
8	0·190		8	0·130		8	0·132		8	0·143		8	0·154	
9	0·110		9	0·085		9	0·050		9	0·076		9	0·085	
10	0·105		10	0·080		10	0·049		10	0·077		10	0·090	
11	0·195		11	0·130		11	0·129		11	0·141		11	0·150	
12	0·100		12	0·080		12	0·051		12	0·075		12	0·182	
13	0·100		13	0·080		13	0·050		13	0·077		13	0·076	
14	0·195		14	0·120		14	0·125		14	0·141		14	0·156	
15	0·100		15	0·080		15	0·051		15	0·076		15	0·083	
16	0·120		16	0·070		16	0·057		16	0·077		16	0·083	
17	0·210		17	0·130		17	0·133		17	0·141		17	0·148	
18	0·100		18	0·080		18	0·050		18	0·076		18	0·076	
19	0·190		19	0·080		19	0·052		19	0·075		19	0·085	
20	0·220		20	0·140		20	0·128		20	0·142		20	0·158	
21	0·120		21	0·085		21	0·049		21	0·077		21	0·082	
22	0·110		22	0·080		22	0·049		22	0·076		22	0·085	
23	0·200		23	0·130		23	0·130		23	0·141		23	0·153	
24	0·105		24	0·080		24	0·050		24	0·075		24	0·090	
25	0·110		25	0·070		25	0·050		25	0·079		25	0·076	
26	0·195		26	0·130		26	0·132		26	0·141		26	0·152	
27	0· —		27	0·075		27	0·050		27	0·076		27	0·082	
28	0· —		28	0·080		28	0·057		28	0·078		28	0·083	
29	0·190		29	0·140		29	0·126		29	0·141		29	0·155	
30	0·094		30	0·080		30	0·050		30	0·076		30	0·076	

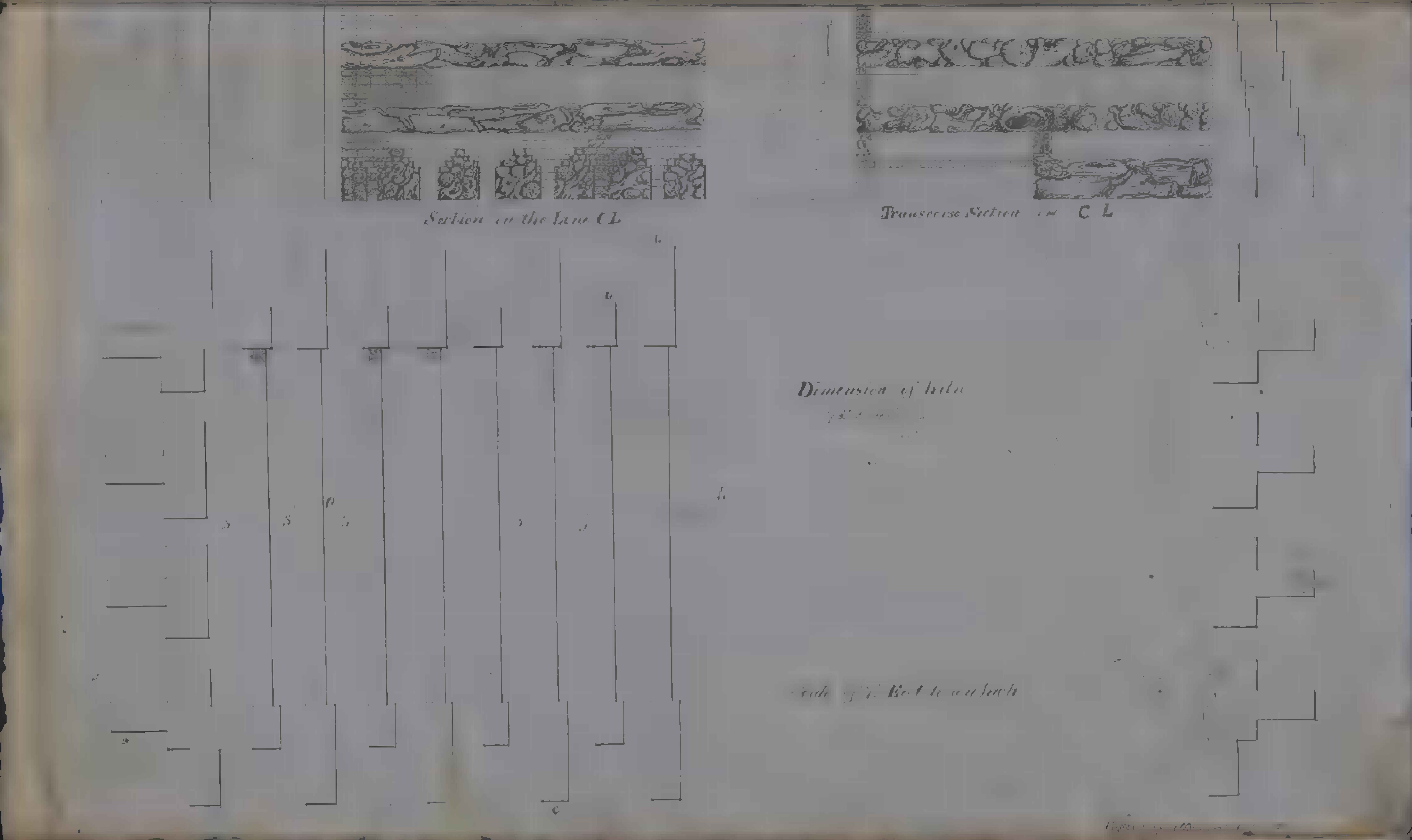
Level Point	No 16 Arch Sinking	No 16 Arch Average	Level Point	No 17 Arch Sinking	No 17 Arch Average	Level Point	No 18 Arch Sinking	No 18 Arch Average	Level Point	No 19 Arch Sinking	No 19 Arch Average	Level Point	No 20 Arch Sinking	No 20 Arch Average
1	0·150	Haunches. Average Sinking 0·0990	1	0·050	Haunches. Average Sinking 0·0880	1	0·140	Haunches. Average Sinking 0·1060	1	0·033	Haunches. Average Sinking 0·0332	1	0·045	Haunches. Average Sinking 0·0265
2	0·285	Crown do 0·1875	2	0·220	Crown do 0·1975	2	0·300	Crown do 0·2335	2	0·132	Crown do 0·1325	2	0·165	Crown do 0·1135
3	0·150		3	0·110		3	0·170		3	0·034		3	0·065	
4	0·120		4	0·080		4	0·120		4	0·032		4	0·035	
5	0·210		5	0·210		5	0·260		5	0·132		5	0·150	
6	0·115		6	0·100		6	0·140		6	0·034		6	0·050	
7	0·105		7	0·090		7	0·110		7	0·035		7	0·030	
8	0·140		8	0·210		8	0·250		8	0·133		8	0·140	
9	0·090		9	0·100		9	0·120		9	0·033		9	0·045	
10	0·085		10	0·095		10	0·115		10	0·034		10	0·020	
11	0·170		11	0·195		11	0·230		11	0·132		11	0·130	
12	0·085		12	0·100		12	0·110		12	0·032		12	0·040	
13	0·080		13	0·085		13	0·110		13	0·033		13	0·020	
14	0·155		14	0·205		14	0·235		14	0·133		14	0·110	
15	0·080		15	0·090		15	0·120		15	0·032		15	0·040	
16	0·085		16	0·085		16	0·115		16	0·033		16	0·020	
17	0·150		17	0·195		17	0·230		17	0·132		17	0·120	
18	0·075		18	0·190		18	0·100		18	0·032		18	0·035	
19	0·090		19	0·090		19	0·110		19	0·032		19	0·000	
20	0·160		20	0·195		20	0·230		20	0·133		20	0·100	
21	0·075		21	0·080		21	0·100		21	0·034		21	0·015	
22	0·085		22	0·100		22	0·100		22	0·035		22	0·000	
23	0·175		23	0·180		23	0·210		23	0·133		23	0·090	
24	0·085		24	0·080		24	0·095		24	0·034		24	0·010	
25	0·090		25	0·100		25	0·095		25	0·032		25	0·020	
26	0·190		26	0·190		26	0·195		26	0·132		26	0·070	
27	0·085		27	0·070		27	0·070		27	0·034		27	0·000	
28	0·120		28	0·090		28	0·010		28	0·034		28	0·040	
29	0·240		29	0·175		29	0·195		29	0·133		29	0·060	
30	0·120		30	0·065		30	0·070		30	0·033		30	0·000	

Report of Sinking in the Arches of the Soldni Aqueduct.

Level Point	No 21 Arch Sinking	No 22 Arch Sinking	No 23 Arch Sinking	No 24 Arch Sinking	No 25 Arch Sinking
1	0·070	0·090	0·087	0·130	0·100
2	0·150	0·210	0·152	0·200	0·140
3	0·065	0·095	0·087	0·115	0·110
4	0·050	0·060	0·088	0·120	0·090
5	0·160	0·175	0·151	0·185	0·140
6	0·040	0·080	0·090	0·105	0·090
7	0·040	0·045	0·086	0·110	0·085
8	0·140	0·130	0·150	0·165	0·130
9	0·045	0·050	0·089	0·100	0·090
10	0·040	0·030	0·087	0·110	0·070
11	0·050	0·130	0·152	0·160	0·120
12	0·030	0·045	0·086	0·090	0·065
13	0·025	0·040	0·087	0·100	0·060
14	0·110	0·125	0·149	0·145	0·110
15	0·025	0·060	0·086	0·025	0·070
16	0·020	0·030	0·086	0·090	0·050
17	0·100	0·120	0·151	0·140	0·095
18	0·020	0·040	0·087	0·070	0·055
19	0·020	0·030	0·086	0·080	0·050
20	0·095	0·115	0·149	0·146	0·090
21	0·011	0·040	0·087	0·070	0·055
22	0·012	0·030	0·089	0·070	0·050
23	0·100	0·120	0·152	0·120	0·095
24	0·010	0·040	0·086	0·070	0·040
25	0·000	0·030	0·090	0·030	0·010
26	0·035	0·120	0·147	0·110	0·080
27	0·011	0·030	0·088	0·040	0·035
28	0·000	0·010	0·087	0·050	0·030
29	0·055	0·110	0·152	0·090	0·070
30	0·000	0·040	0·087	0·020	0·035
Haunches Average Sinking	0·0272	0·0457	0·0873	0·0897	0·0620
Crown do	0·1155	0·1355	0·1509	0·1460	0·1060

Level Point	No 26 Arch Sinking	No 27 Arch Sinking	No 28 Arch Sinking	No 29 Arch Sinking	No 30 Arch Sinking
1	0·140	0·055	0·055	0·065	0·035
2	0·240	0·133	0·145	0·125	0·125
3	0·150	0·065	0·065	0·050	0·010
4	0·140	0·064	0·075	0·068	0·045
5	0·220	0·135	0·135	0·125	0·115
6	0·150	0·064	0·065	0·040	0·020
7	0·115	0·065	0·075	0·060	0·045
8	0·195	0·132	0·145	0·130	0·125
9	0·125	0·060	0·075	0·055	0·030
10	0·110	0·070	0·090	0·070	0·055
11	0·175	0·136	0·155	0·130	0·130
12	0·120	0·053	0·075	0·040	0·035
13	0·100	0·065	0·080	0·060	0·055
14	0·175	0·134	0·160	0·135	0·125
15	0·160	0·070	0·070	0·050	0·040
16	0·090	0·060	0·085	0·060	0·065
17	0·113	0·133	0·155	0·130	0·135
18	0·110	0·063	0·085	0·050	0·040
19	0·085	0·055	0·095	0·060	0·065
20	0·160	0·135	0·165	0·135	0·130
21	0·100	0·064	0·095	0·065	0·045
22	0·085	0·065	0·090	0·060	0·065
23	0·150	0·134	0·160	0·145	0·135
24	0·090	0·064	0·100	0·060	0·055
25	0·070	0·065	0·085	0·070	0·075
26	0·140	0·133	0·160	0·135	0·140
27	0·090	0·070	0·090	0·055	0·050
28	0·075	0·065	0·095	0·090	0·075
29	0·140	0·135	0·170	0·145	0·125
30	0·080	0·048	0·110	0·065	0·065
Haunches Average Sinking	0·1067	0·0620	0·0790	0·0601	0·0435
Crown do	0·1708	0·1340	0·1550	0·1335	0·1305

Hauger, 2d V. iii


Section on the Line C L
Transverse Section on C L

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